PINE FLAT UNIT 4 PROJECT

WATER TO WIRE EQUIPMENT PROCURMENT PACKAGE

BID SOLICITATION # 203.02.95

Procurement Requirements

7. Drawings

PINE FLAT UNIT-4 PROJECT
WATER TO WIRE EQUIPMENT PROCUREMENT PACKAGE

INVITATION FOR BIDS

Notice is hereby given that electronically submitted bids will be received until the hour of 2:00 PM Pacific Standard Time (PST), February 1, 2023 on www.bidnetdirect.com platform (Solicitation number: 203.02.95), the web-based bid posting platform used by Kings River Conservation District (KRCD), herein after referred to as Owner, for the procurement of turbine, generator, valve, electrical equipment and appurtenances for installation by others at the Pine Flat Unit-4 addition at the existing Pine Flat Hydroelectric Power Project, as more fully described in the Procurement Documents. Stantec Consulting Services, Inc. has been hired by the Owner as the Owner's Engineer for this project, herein after referred to as Engineer.

Bidders may send questions regarding the bid in the form of Request for Information (RFI). Last date for RFIs submission is January 6, 2023, by 4:00 PM PST.

Bids will be privately evaluated and will thereafter be accepted or rejected by the Owner within 90 days. The owner may opt to implement a two-stage selection process and may only select four (4) to six (6) qualified bidders to move forward with detailed bid evaluation process.

Bids are requested for Goods and Services, for the design, manufacture, testing and delivery to Owner of one suitably sized "small" Horizontal turbine, one horizontal synchronous generator, one turbine shutoff valve, and electrical equipment and miscellaneous and auxiliary equipment and components, as more fully described in the Procurement Documents.

Bid documents shall be downloaded from the web-based platform www.bidnetdirect.com. Bid documents consist of Bidding Requirements, Procurement Specification and Drawings, and Bid Forms. Bidders are informed that these documents will be required in the preparation of bids. Each bid must be submitted on the prescribed Bid Forms and must be for all Contract items.

Bidder must deposit with his Bid, security in the amount, form and subject to the conditions stated in the Instructions to Bidders.

Bidder will be required to submit with his Bid evidence of his qualifications to perform the Work satisfactorily. Successful Bidder must furnish a Performance Bond in the amount of the total Bid.

Owner reserves the right in its sole discretion after opening bids to waive any and all irregularities in any bid, to reject any or all bids, or to award the Contract to the responsible Bidder whose bid prices and supporting data provide the lowest price for overall project construction and operation, as more fully described in the Procurement Documents. The award of the Contract, if it is awarded, will be made within one hundred-twenty days after the final bid submission date. It shall be noted that KRCD plans to issue a separate Request for Bid for the EPC contract to construct Unit-4 powerhouse within February, 2023 and that the contract date award for the water to wire Equipment package will align with the contract for the EPC. Owner shall notify all bidders of the outcome.

Dated at Fresno, California this 21st day of November, 2022.

Kings River Conservation District

David Merritt, General Manager

INSTRUCTIONS TO BIDDERS

INSTRUCTIONS TO BIDDERS

TABLE OF ARTICLES

ARTICLE 1 - DEFINED TERMS

1.01 Terms used in these Instructions to Bidders will have the meanings indicated in the General Conditions and Supplementary Conditions. Additional terms used in these Instructions to Bidders have the meanings indicated below which are applicable to both the singular and plural thereof:

ARTICLE 2 - BIDS RECEIVED

2.01 Refer to Invitation to Bid for information on receipt of Bids.

ARTICLE 3 - COPIES OF BIDDING DOCUMENTS

3.01 A complete set of the Bidding Documents may be obtained from the. KRCD's website www.krcd.org/#rfp or bidnetdirect.com

3.02 Complete sets of the Bidding Documents shall be used in preparing Bids; neither Buyer nor Engineer assumes any responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bidding Documents.

3.03 Buyer and Engineer in making copies of Bidding Documents available on the above terms do so only for the purpose of obtaining Bids for furnishing Goods and Special Services and do not confer a license or grant for any other use.

ARTICLE 4 - QUALIFICATIONS OF BIDDERS

4.01 To demonstrate Bidder's qualifications to furnish Goods and Special Services, within five days of Buyer's request, Bidder shall submit written evidence, such as financial data, previous experience, and such other data as may be called for below.

A. Location, and Size of Manufacturing Plant and capacity to produce the Goods.

B. Proof of necessary capital to begin promptly and to complete the Goods within the specified schedule.

C. Manufacturing experience, including the type, size, location and service of previously manufactured similar material and equipment.

4.02 To demonstrate that Bidder has not colluded with any other parties in the preparation of it's Bid, Bidder shall submit a Non-Collusion Statement with it's Bid.

ARTICLE 5 - EXAMINATION OF BIDDING DOCUMENTS AND POINT OF DESTINATION

5.01 Upon request Buyer will provide *Bidder* access to the Point of Destination to conduct such investigations, examinations, tests and studies as Bidder deems necessary for submission of a Bid.

5.02 It is the responsibility of each Bidder before submitting a Bid to:

A. examine and carefully study the Bidding Documents, including any Addenda and the related data identified in the Bidding Documents;

B. if specified, or if, in Bidder's judgment, any local condition may affect cost, progress or the furnishing of Goods and Special Services, visit the Point of Destination to become familiar with the local conditions;

C. become familiar with and satisfy Bidder as to all federal, state, and local Laws and Regulations that may affect cost, progress, or the furnishing of Goods and Special Services;

D. carefully study and correlate the information known to Bidder, and information and observations obtained from Bidder's visits, if any, to the Point of Destination, with the Bidding Documents;

E. promptly give Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Bidder discovers in the Bidding Documents and confirm that the written resolution thereof by Engineer is acceptable to Bidder; and

F. determine that the Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for furnishing Goods and Special Services.

5.03 The submission of a Bid will constitute an incontrovertible representation by Bidder that Bidder has complied with every requirement of this Article 5, that without exception the Bid is premised upon furnishing Goods and Special Services required by the Bidding Documents, that Bidder has given Engineer written notice of all conflicts, errors, ambiguities and discrepancies that Bidder has discovered in the Bidding Documents and the written resolutions thereof by Engineer are acceptable to Bidder, and that the Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for furnishing Goods and Special Services.

ARTICLE 6 - PRE-BID CONFERENCE

Deleted.

ARTICLE 7 - INTERPRETATIONS

7.01 All questions about the meaning or intent of the Bidding Documents are to be submitted to Engineer in writing. Interpretations or clarifications considered necessary by Engineer in response to such questions will be issued by Addenda mailed or delivered to all parties recorded by Engineer as having received the Bidding Documents. Questions received less than ten days prior to the date for opening of Bids will not be answered. Only answers in the Addenda will be binding. Oral and other interpretations or clarifications will be without legal effect.

7.02 Addenda may be issued to clarify, correct, or change the Bidding Documents as deemed advisable by Buyer or Engineer.

ARTICLE 8 - BID SECURITY

8.01 A Bid must be accompanied by Bid security made payable to Buyer, in an amount of 10 percent of Bidder's maximum Bid price and in the form of a certified or bank check or a Bid Bond [on form attached] issued by a surety meeting the requirements of Paragraph 4.01.B of the General Conditions.

8.02 The Bid security of the apparent Successful Bidder will be retained until such Bidder has executed the Agreement, furnished the required contract security and met the other conditions of the Notice of Award, whereupon the Bid security will be returned. If the apparent Successful Bidder fails to execute and deliver the Agreement, and furnish the required contract security within 15 days after the Notice of Award, Buyer may annul the Notice of Award and the Bid Security of that Bidder will be forfeited. The Bid security of other Bidders whom Buyer believes to have a reasonable chance of receiving the award may be retained by Buyer until the earlier of seven days after the Effective date of the Agreement or 61 days after the Bid opening, whereupon Bid security furnished by such Bidders will be returned.

8.03 Bid security of other Bidders whom Buyer believes do not have a reasonable chance of receiving the award will be returned within seven days after the Bid opening.

ARTICLE 9 - CONTRACT TIMES

9.01 See applicable provisions in the Agreement.

ARTICLE 10 - LIQUIDATED DAMAGES

10.01 Provisions for liquidated damages, if any, are set forth in the Agreement.

ARTICLE 11 - "OR-EQUAL" ITEMS

11.01 The Contract, if awarded, will be on the basis of material and equipment specified or described in the Bidding Documents without consideration of possible "or-equal" items. Whenever it is specified or described in the Bidding Documents that an "or-equal" item of material or equipment may be furnished or used by Seller if acceptable to Engineer, application for such acceptance will not be considered by Engineer until after the Effective Date of the Agreement. The procedure for submittal of any such application by Seller and consideration by Engineer is set forth in the General Conditions and may be supplemented in the General Requirements.

ARTICLE 12 - PREPARATION OF BID

12.01 The Bid Form is included with the Bidding Documents. Additional copies may be obtained from Engineer.

12.02 All blanks on the Bid Form shall be completed by printing in ink or by typewriter and the Bid signed. A Bid price shall be indicated for each Bid item listed therein, or the words "No Bid", "No Change," or "Not Applicable" entered.

12.03 A Bid by a corporation shall be executed in the corporate name by the president or a vice-president or other corporate officer accompanied by evidence of authority to sign. The corporate seal shall be affixed and attested by the secretary or an assistant secretary. The corporate address and state of incorporation shall be shown below the signature.

12.04 A Bid by a partnership shall be executed in the partnership name and signed by a partner (whose title must appear under the signature) accompanied by evidence of authority to sign. The official address of the partnership shall be shown below the signature.

12.05 A Bid by a limited liability company shall be executed in the name of the firm by a member and accompanied by evidence of authority to sign. The state in which the firm was formed and the official address of the firm shall be shown below the signature.

12.06 A Bid by an individual shall show the Bidder's name and official address.

12.07 A Bid by a joint venture shall be executed by each joint venturer in the manner indicated on the Bid Form. The official address of the joint venture shall be shown below the signature.

12.08 All names must be typed or printed in ink below the signature.

12.09 The Bid shall contain an acknowledgment of receipt of all Addenda, the numbers of which shall be filled in on the Bid Form.

12.10 The address and telephone number for communications regarding the Bid shall be shown.

12.11 The Bid shall contain evidence of Bidder's authority and qualification to do business in the state of the Point of Destination or covenant to obtain such qualification prior to award of the Contract.

ARTICLE 13 - BASIS OF BID; COMPARISON OF BIDS

13.01 *Series of Lump Sums*

A. Bidder shall submit a Bid for each lump sum item as set forth on the Bid Form, and shall compute and enter the total of all lump sum items in the space provided on the Bid Form.

B. For determination of the apparent low Bid, Bids will be compared on the basis of the total of all lump sum items.

C. Discrepancies between the indicated sum of any column of figures and the correct sum thereof will be resolved in favor of the arithmetically correct sum. Discrepancies between words and figures will be resolved in favor of the words.

13.02 *Bid Evaluation*

A. The Bid Form contains a table of expected operating data for the new turbine-generator. The Bidder is required to complete the table with guaranteed efficiencies. The completed table will be used to calculate an expected average annual energy amount.

ARTICLE 14 - SUBMITTAL OF BID

14.01 Each prospective Bidder is furnished one copy of the Bidding Documents with one separate unbound copy each of the Bid Form and the required Bid Bond Form. The unbound copy of the Bid Form is to be completed and submitted with the Bid security and supporting data, as listed in the Bid Form.

14.02 A Bid shall be submitted no later than the date and time prescribed and at the place indicated in the Invitation to Bid and shall be uploaded to the bidnetdirect.com response portal with an email confirmation to Owner's Project Manager and a copy to the Engineer's Project Manager, after uploading all required bid documents; the date and time of submittal of the bid shall be indicated in the email.

1. Owner, Kings River Conservation District, 4886 E. Jensen Ave, Fresno, CA 95835
   Project Manager: Pawan Niroula
   Email: pniroula@krcd.org

2. Engineer, Stantec Consulting Services, 1340 Treat Boulevard, Suite 300, Walnut Creek, CA 94597
   Project Manager: Uddhav Lakkundi, PE, PMP
   Email: uddhav.lakkundi@stantec.com

As a cautionary measure, bidders are also advised to prepare a secondary submission method in case there are any technical difficulties in the platform to upload all required bid documents.

All the Request for Information (RFI) during the bid process shall be emailed to the Engineer's Project Manager with a copy to the Owner's Project Manager. The subject line shall mention the keywords- "RFI-PINE FLAT UNIT-4 PROJECT (TOPIC)". Multiple questions can be included within the same RFI. The last date of RFI (and any other questions) submission shall be no later than the date and time prescribed in the Invitation to Bid.

ARTICLE 15 - MODIFICATION OR WITHDRAWAL OF BID

15.01 A Bid may be modified or withdrawn by a document executed in the manner that a Bid must be executed, and delivered to the place where Bids are to be submitted prior to the date and time for the opening of Bids.

15.02 If, within 24 hours after Bids are opened, any Bidder files a signed written notice with Buyer and promptly thereafter demonstrates to the reasonable satisfaction of Buyer that there was a material and substantial mistake in the preparation of its Bid, it may withdraw its Bid, and its Bid security will be returned. Thereafter, if the Goods and Special Services are rebid, that Bidder will be disqualified from further bidding on the Goods and Special Services to be furnished under the Contract Documents.

ARTICLE 16 - OPENING OF BIDS

16.01 All bids will be received electronically in a PDF format via web-based platform bidnetdirect.com. Owner and Engineer will start evaluating the bids after the final bid submission date. An abstract of the amounts of the Bids and Alternate Bids, if any, will not be made available to Bidders after or during the evaluation of the Bids.

ARTICLE 17 - BIDS TO REMAIN SUBJECT TO ACCEPTANCE

17.01 All Bids will remain subject to acceptance for the period of time stated in the Bid Form, but Buyer may, in its sole discretion, release any Bid and return the Bid security prior to the end of this period.

ARTICLE 18 - AWARD OF CONTRACT

18.01 Buyer reserves the right to reject any and all Bids, including without limitation, nonconforming, nonresponsive, unbalanced, or conditional Bids. Buyer further reserves the right to reject the Bid of any Bidder whom it finds, after reasonable inquiry and evaluation, to be non-responsible. Buyer may also reject the Bid of any Bidder if Buyer believes that it would not be in the best interest of the Buyer to make an award to that Bidder. Buyer also reserves the right to waive all informalities not involving price, time or changes in the Goods and Special Services, and to negotiate contract terms with the Successful Bidder.

18.02 More than one Bid for the same Goods and Special Services from an individual or entity under the same or different names will not be considered. Reasonable grounds for believing that any Bidder has an interest in more than one Bid for the Goods and Special Services shall be cause for disqualification of that Bidder and the rejection of all Bids in which that Bidder has an interest.

18.03 In evaluating Bids, Buyer will consider whether or not the Bids comply with the prescribed requirements, and such alternatives, unit prices and other data, as may be requested in the Bid Form or may be requested from Bidders prior to a Notice of Award.

18.04 In evaluating Bids, Buyer will consider the qualifications of the Bidders.

18.05 Buyer may implement a two-stage selection process- only the top four(4) to six(6) most qualified bidders will be considered for the further bid evaluation.

18.05 Buyer may conduct such investigations as Buyer deems necessary to establish the responsibility, qualifications, and financial ability of Bidder’s proposed subcontractors, suppliers, individuals, or entities to furnish parts of the Goods and Special Services in accordance with the Contract Documents.

18.06 If the Contract is to be awarded, Buyer will award the Contract to the Bidder whose Bid is in the best interest of Buyer.

18.07 Bidder may submit an alternative proposal(s) that could potentially offer better pricing and technology than described by the specifications. Alternative proposal will be equally considered during the bid evaluation process.

ARTICLE 19 - CONTRACT SECURITY AND INSURANCE

19.01 Article 4 of the General Conditions sets forth Buyer’s requirements as to performance and other bonds and insurance. When the Successful Bidder delivers the executed Agreement to Buyer, it must be accompanied by the required performance and other bonds.

ARTICLE 20 - SIGNING OF AGREEMENT

20.01 When Buyer gives a Notice of Award to Successful Bidder, it shall be accompanied by the required number of unsigned counterparts of the Agreement with the other Contract Documents which are to be identified in the Agreement and attached thereto. Within 15 days thereafter, Successful Bidder shall sign and deliver the required number of counterparts of the Agreement and attached documents to Buyer. Within ten days thereafter, Buyer shall deliver one fully signed counterpart to Successful Bidder with a complete set of Drawings with appropriate identification.

ARTICLE 21 - SALES AND USE TAXES

21.01 Buyer is not exempt from California state or Fresno County sales and use taxes on materials and equipment to be incorporated in the Project. Said taxes shall be included in the Bid.

ARTICLE 22 - RETAINAGE

22.01 Provisions concerning Seller's rights to deposit securities in lieu of retainage are set forth in the Agreement.

ARTICLE 23 - CONTRACT TO BE ASSIGNED

23.01 The Equipment Procurement Contract will not be assigned.

SECTION 00500
BIDDER'S DATA

The following attachments shall be submitted with the bidder's proposals. Failure to provide the requested information may result in rejection of the Bidder's proposal if the owner determines that the missing data is necessary to properly evaluate the Bidder's proposal.

Attachment A. Bidder's Qualifications

Attachment B. Unit Performance and Characteristics

Attachment C. Technical Data

Attachment D. Basis of Design

Attachment E. List of Sub-suppliers

Attachment F. Preliminary Progress Schedule

Attachment G. Alternatives

Attachment H. Load List for estimated load consumption

Attachment I. Exceptions and Clarifications

Attachment J. Major Assumptions

Attachment K. Proprietary design

Attachment L. O&M Data and Costs

ATTACHMENT A – BIDDER'S QUALIFICATIONS

A. Proposal submitted by:

____

(Typed Name of Bidder)

B. The following data, statements of experience, personnel, equipment and general qualifications of the Bidder are submitted as part of the Proposal and the Bidder represents and guarantees the truthfulness and accuracy thereof.

1. Our organization has been in business continuously from the year ____.
2. Our organization has had experience in work comparable to that required by the Contract Documents for ___ years.
3. Bidder will design, manufacture, test and provide services according to their Quality Assurance Program that is ISO ____________________ certified, dated _______________________.
4. Bidder is:

   a. An Individual

   ____.

   b. A partnership

   ____.

   c. A Corporation

   ____.

   d. Type of business

   ____.

5. If Bidder is a corporation, please identify:

   a. State of incorporation,

   ____.

b. Name of address of registered agent

____.

C. Financial Information

1. Is any litigation pending against Bidder? ________Yes ________ No, If yes, please provide details:

____

____

____

____.

2. Has Bidder commenced any litigation in the past five years against another party which is related to suitability of a product furnished or work performed by Bidder?

_______ Yes _______ No.

3. Attach a statement of Financial Condition, including Bidder's latest regular, dated financial statement or balance sheet prepared in accordance with generally accepted accounting principles.

D. Statement of Qualifications

Bidder's previous experience and qualifications are of great importance to the Owner and will be evaluated prior to award of this contract. Append a detailed description of Bidder's previous experience that demonstrates the following turbine-generator equipment experience similar to that specified and required in these Specifications in sufficient detail for the Owner to determine if the Bidder meets the following minimum requirements:

1. The Bidder shall have the minimum of twenty (20) years-experience in designing, manufacturing, testing, and commissioning turbine-generator equipment of approximately the same size, capacity and design complexity to that specified and required. The 20-year requirement regarding experience also applies to the sub-suppliers of major parts and components.

E. Key personnel

The experience and qualifications of key personnel are of great importance to the owner and will be evaluated prior to award of this Contract. Append resumes and qualifications of the following key personnel demonstrating their experience in sufficient detail for the Owner to determine if key personnel assigned to this Contract meet the following minimum requirements:

1. The Bidder's nominated project manager shall have a minimum of ten (10) years of experience and five (5) projects involving turbine-generators of approximately the same size, capacity, and design complexity to that specified and requirement. Information on the five (5) reference projects with contact information shall be included in the Bidder's proposal.
2. The Bidder's project engineer or design lead shall have a minimum of ten (10) years of experience and five (5) projects involving turbine-generators of approximately the same size, capacity, and design complexity to that specified and required. Information on the five (5) reference projects with contact information shall be included in the Bidder's proposal.
3. The Bidder's electrical and controls engineer or electrical and controls design lead shall have a minimum of ten (10) years of experience and five (5) projects involving turbine-generators and electrical/controls design of approximately the same size, capacity, and design complexity to that specified and required. Information on the five (5) reference projects with contact information shall be included in the Bidder's proposal.
4. The Bidder's field services representative shall have a minimum of ten (10) years of experience and five (5) projects involving turbine-generator installations of approximately the same size, capacity, and design complexity to that specified and required. Information on the five (5) reference projects with contact information shall be included in the Bidder's proposal.

Any changes to key personnel after award shall be approved by the Owner.

F. Technical and Field Service Support

1. The Bidder's ability to provide prompt technical and field service support are an important consideration for the Owner. The Supplier/Bidder shall have an engineering support team located in North America that can respond to service calls from the Owner during the warranty period. The engineering support team shall be familiar with the design, operations, and maintenance required for the furnished equipment.
2. The Bidder shall indicate the name(s) and location(s) for providing technical and field service support. If Bidder subcontracts field support to a separate service shop, then the name of this entity shall also be provided.

ATTACHMENT B – UNIT PERFORMANCE AND CHARACTERISITICS

1.01 GENERAL

A. Failure to provide all the information and data required as indicated by this attachment may result in rejection of the Bidder's Proposal.

B. Net head when used in this document shall be interpreted as net head at the turbine inlet.

1.02 CHARACTERISTICS – HORIZONTAL FRANCIS TURBINE (BASE BID)

A. Expected Performance.

Bidder shall provide all curves and tabulations of expected performance covering at a minimum, the range of 5 percent to maximum output over the full range of operating heads. Curves shall include the following:

1. The relationship between flow, head, efficiency, and power output (at turbine shaft).
2. Percentage opening versus flow for wicket gate position 0% to 100%.
3. The curves shall cover the full range of operating heads, based on Bidder's design and shall show the cavitation limits for the turbine.

B. The performance provided herein shall be based on acceptable operation, without objectionable or detrimental power surges, cavitation, or perceptible vibration within the specified performance envelope.

C. Runaway Speed and Discharge.

The maximum possible runaway speed of the turbine when operating at full gate under Bidder's proposed maximum operating gross head and with no load on the generator, except windage and friction, is calculated to be not more than:

1. ______ rpm (for a maximum on-cam runaway speed), corresponding to a discharge of ______ cfs.
2. ______ rpm (for a maximum off-cam runaway speed), corresponding to a discharge of ______ cfs.

D. Hydraulic Thrust.

The maximum hydraulic thrust under any operating condition shall be no more than ____________ lbs.

E. Wicket Gate Leakage.

The maximum leakage past the closed wicket gates under a static head of 260 ft. shall be not more than ______ gpm.

F. Cavitation Pitting Guarantee.

The turbine shall be guaranteed against excessive pitting caused by cavitation as defined in Section 01750. The maximum loss of metal from the turbine runner, discharge ring, and draft tube combined caused by cavitation, erosion, or pitting during the first 8,000 hours of operation shall not be more than ________ pounds for the runner and _________ pounds for the wetted embedded parts.

G. Vibration.

After assembly of the turbine-generator, absolute shaft vibration levels measured at all guide bearings (driven side guide bearing and non-driven side guide bearing) under normal operating conditions shall not be more than _________ mils peak-to-peak.

H. Turbine Output.

The turbine shall produce not less than ______________ kW without exceeding its cavitation limit when operating at rated speed of 400 rpm under a net head of _____ ft.

I. Turbine Peak Efficiency.

The point of maximum efficiency of the turbine operating at rated speed shall be not less than the operating points stated below:

1. Net Head: ____________ ft.
2. Efficiency: ____________ %.
3. Turbine Output: ________kW.

J. Turbine Efficiency.

The turbine shall have the efficiencies stated on the following page without exceeding its cavitation limit when operating at rated speed under the net heads and corresponding tailwater elevations indicated below and with water temperature of 65°F.

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (R)	Turbine Efficiency (%) (E)	Product (RXE)	Turbine Output (kW)	Cavitation Limit Upper/Lower
60	728	613.7	110	109.4	4.44				/
120	728	613.7	110	107.5	8.28				/
180	728	613.7	110	104.5	6.00				/
240	728	613.7	110	100.3	3.39				/
300	728	613.7	110	94.9	1.72				/
60	756	613.7	128	127.4	4.83				/
120	756	613.7	128	125.5	15.17				/
180	756	613.7	128	122.5	4.94				/
240	756	613.7	128	118.3	2.22				/
300	756	613.7	128	112.9	1.72				/
60	764	613.7	146	145.4	4.72				/
120	764	613.7	146	143.5	14.33				/
180	764	613.7	146	140.5	4.5				/
240	764	613.7	146	136.3	1.61				/
300	764	613.7	146	130.9	1.11				/
60	782	613.7	164	163.4	3.83				/
120	782	613.7	164	161.5	9.28				/
180	782	613.7	164	158.5	2.06				/
240	782	613.7	164	154.3	1.33				/
300	782	613.7	164	148.9	0.78				/
60	800	613.7	182	181.4	2.78				/
120	800	613.7	182	179.5	4.00				/
180	800	613.7	182	176.5	2.22				/
240	800	613.7	182	172.3	0.11				/

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (R)	Turbine Efficiency (%) (E)	Product (RXE)	Turbine Output (kW)	Cavitation Limit Upper/Lower
300	800	613.7	182	166	0.00				/
60	818	613.7	200	199.4	2.28				/
120	818	613.7	200	197.5	2.94				/
180	818	613.7	200	194.5	0.50				/
240	818	613.7	200	190.3	0.17				/
300	818	613.7	200	184.9	0.17				/
60	836	613.7	218	217.4	2.06				/
120	836	613.7	218	215.5	2.61				/
180	836	613.7	218	212.5	2.94				/
240	836	613.7	218	208.3	2.33				/
300	836	613.7	218	202.9	1				/
60	854	613.7	236	235.4	7.06				/
120	854	613.7	236	233.5	1.72				/
180	854	613.7	236	230.5	1.72				/
240	854	613.7	236	226.3	2.00				/
300	854	613.7	236	220.9	3.11				/
60	872	613.7	254	253.4	1.89				/
120	872	613.7	254	251.5	1.22				/
180	872	613.7	254	248.5	0.67				/
240	872	613.7	254	244.3	1.89				/
300	872	613.7	254	238.9	2.06				/

Table 1.02.1 Guaranteed Turbine Performance (Base Bid with 400 rpm)

1.03 CHARACTERISTICS – HORIZONTAL FRANCIS TURBINE (ALTERNATE BID)

A. General:

Should the Bidder determine that the site characteristics are better suited by an alternatively rated unit, the Bidder is allowed to offer a unit speed different than that specified for the Base Bid, so as to compare the cost of the unit together with their relative merits in terms of performance, efficiency, and other pertinent factors prior to award. For bidding purposes the Base Bid assumes a unit rated speed of 400 rpm, whereas the Alternative Bid allows for another speed that may be preferred or recommended by the Bidder. See Attachment G for further information.

B. Expected Performance.

Bidder shall provide all curves and tabulations of expected performance covering at least, the range of 5 percent to maximum output over the full range of operating heads. Curves shall include the following:

1. The relationship between flow, head, efficiency, and power output (at turbine shaft).
2. Percentage opening versus flow for wicket gate position 0% to 100%.
3. The curves shall cover the full range of operating heads based on Bidder's design and shall show the cavitation limits for the turbine.

C. The performance provided herein shall be based on acceptable operation, without objectionable or detrimental power surges, cavitation, or perceptible vibration within the specified performance envelope.

D. Runaway Speed and Discharge.

The maximum possible runaway speed of the turbine when operating at full gate under a gross head of 260 ft and with no load on the generator, except windage and friction, is calculated to be not more than:

1. ________ rpm (for maximum on-cam runaway speed), corresponding to a discharge of ________ cfs.
2. ________ rpm (for maximum off-cam runaway speed), corresponding to a discharge of ________ cfs.

E. Hydraulic Thrust.

The maximum hydraulic thrust under any operating condition shall be no more than _____________ pounds.

F. Wicket Gate Leakage.

The maximum leakage past the closed wicket gates under a static head of 260 ft shall be not more than __________ gpm.

G. Cavitation Pitting Guarantee.

The turbine shall be guaranteed against excessive pitting caused by cavitation as defined in Section 01750. The maximum loss of metal from the turbine runner, discharge ring, and draft tube combined caused by cavitation, erosion, or pitting during the first 8,000 hours of operation shall not be more than ________ pounds for the runner and _________ pounds for the wetted embedded parts.

H. Vibration.

After assembly of the turbine-generator, absolute shaft vibration levels measured at all guide bearings (driven side guide bearing and non-driven side guide bearing) under normal operating conditions shall not be more than _________ mils peak-to-peak.

I. Turbine Output.

The turbine shall produce not less than ______________ kW without exceeding its cavitation limit when operating at rated speed of ____ rpm under a net head of 250 ft.

J. Turbine Peak Efficiency.

The point of maximum efficiency of the turbine operating at rated speed shall be not less than the operating points stated below:

1. Net Head: ____________ ft.
2. Efficiency: ____________ %.
3. Turbine Output: ________kW.

K. Turbine Efficiency.

The turbine shall have the efficiencies stated on the following page without exceeding its cavitation limit when operating at rated speed under the net heads and corresponding tailwater elevations indicated below and with water temperature of 65°F.

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (R)	Turbine Efficiency (%) (E)	Product (RXE)	Turbine Output (kW)	Cavitation Limit Upper/Lower
60	728	618	110	109.4	4.44				/
120	728	618	110	107.5	8.28				/
180	728	618	110	104.5	6.00				/
240	728	618	110	100.3	3.39				/
300	728	618	110	94.9	1.72				/
60	756	618	128	127.4	4.83				/
120	756	618	128	125.5	15.17				/
180	756	618	128	122.5	4.94				/
240	756	618	128	118.3	2.22				/
300	756	618	128	112.9	1.72				/
60	764	618	146	145.4	4.72				/
120	764	618	146	143.5	14.33				/
180	764	618	146	140.5	4.5				/
240	764	618	146	136.3	1.61				/
300	764	618	146	130.9	1.11				/
60	782	618	164	163.4	3.83				/
120	782	618	164	161.5	9.28				/
180	782	618	164	158.5	2.06				/
240	782	618	164	154.3	1.33				/
300	782	618	164	148.9	0.78				/
60	800	618	182	181.4	2.78				/
120	800	618	182	179.5	4.00				/
180	800	618	182	176.5	2.22				/
240	800	618	182	172.3	0.11				/

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (R)	Turbine Efficiency (%) (E)	Product (RXE)	Turbine Output (kW)	Cavitation Limit Upper/Lower
300	800	618	182	166	0.00				/
60	818	618	200	199.4	2.28				/
120	818	618	200	197.5	2.94				/
180	818	618	200	194.5	0.50				/
240	818	618	200	190.3	0.17				/
300	818	618	200	184.9	0.17				/
60	836	618	218	217.4	2.06				/
120	836	618	218	215.5	2.61				/
180	836	618	218	212.5	2.94				/
240	836	618	218	208.3	2.33				/
300	836	618	218	202.9	1				/
60	854	618	236	235.4	7.06				/
120	854	618	236	233.5	1.72				/
180	854	618	236	230.5	1.72				/
240	854	618	236	226.3	2.00				/
300	854	618	236	220.9	3.11				/
60	872	618	254	253.4	1.89				/
120	872	618	254	251.5	1.22				/
180	872	618	254	248.5	0.67				/
240	872	618	254	244.3	1.89				/
300	872	618	254	238.9	2.06				/

Table 2.03.1 Guaranteed Turbine Performance (Alternate Bid with ____rpm)

1.04 CHARACTERISTICS – GENERATOR (BASE BID)

A. Generator Rating and Characteristics.

1. Full load capacity (kVA) at .90 power factor, 85°C temperature rise _______kVA
2. Maximum MW Ramp Rate: ______MW/min
3. Maximum generator losses at 0.9 pf and the following percentage of full rated output:

	Armature I^2R Loss (kW)	Field I^2R Loss (kW)	Stray Load (kW)	Core Loss (kW)	Friction & Windage Loss (kW)	Total Loss (kW)
100%						
75%						
50%						
25%						

1.05 CHARACTERISTICS – GENERATOR (ALTERNATE BID)

A. Generator Rating and Characteristics.

1. Full load capacity (kVA)at .90 power factor, 85°C temperature rise ______kVA
2. Maximum MW Ramp Rate: ________ MW/min
3. Maximum generator losses at 0.9 pf and the following percentage of full rated output:

	Armature I^2R Loss (kW)	Field I^2R Loss (kW)	Stray Load (kW)	Core Loss (kW)	Friction & Windage Loss (kW)	Total Loss (kW)
100%						
75%						
50%						
25%						

1.06 GUARANTEED CHARACTERISTICS – COMBINED TURBINE-GENERATOR (BASE BID)

A. Expected Performance.

Bidder shall provide all curves and tabulations of expected performance covering at a minimum, the range of 5 percent to maximum output over the full range of operating heads. Curves shall include the following:

1. The relationship between flow, head, efficiency, and power output (at generator terminals).
2. Percentage opening versus flow for wicket gate position 0% to 100%.
3. The curves shall cover the full range of operating heads based on Bidder's design and shall show the cavitation limits for the turbine.

B. The performance provided herein shall be based on acceptable operation, without objectionable or detrimental power surges, cavitation, or perceptible vibration within the specified performance envelope.

C. Guaranteed Turbine-Generator Output.

The turbine-generator is guaranteed to produce not less than ___________ kW at 0.9pf, measured at the generator terminals, without exceeding the turbine cavitation and generator temperature rise limits and operating at 400 rpm under a net head of the turbine design.

D. Guaranteed Turbine-Generator Peak Efficiency.

The point of maximum efficiency of the turbine-generator operating a rated speed, 1.0pf, is guaranteed to be not less than stated below:

1. Net Head: _______ ft.
2. Efficiency: _______ %.
3. Turbine-Generator Output: _________ kW at 1.0pf, measured at the generator terminals.

E. Guaranteed Turbine-Generator Efficiency.

The turbine-generator is guaranteed to have the efficiencies stated on the following pages without exceeding the turbine cavitation and generator temperature rise limits when operating at rated speed under the net heads and corresponding tailwater elevations indicated below and with water temperatures of 65°F.

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@0.9pf)	Guaranteed WAE* Production (kWh)
60	728	618	110	109.4	106.7			
120	728	618	110	107.5	198.7			
180	728	618	110	104.5	144.0			
240	728	618	110	100.3	81.3			
300	728	618	110	94.9	41.3			
60	756	618	128	127.4	116.0			
120	756	618	128	125.5	364.0			
180	756	618	128	122.5	118.7			
240	756	618	128	118.3	53.3			
300	756	618	128	112.9	41.3			
60	764	618	146	145.4	113.3			
120	764	618	146	143.5	344.0			
180	764	618	146	140.5	108.0			
240	764	618	146	136.3	38.7			
300	764	618	146	130.9	26.7			
60	782	618	164	163.4	92.0			
120	782	618	164	161.5	222.7			
180	782	618	164	158.5	49.3			
240	782	618	164	154.3	32.0			
300	782	618	164	148.9	18.7			
60	800	618	182	181.4	66.7			
120	800	618	182	179.5	96.0			
180	800	618	182	176.5	53.3			
240	800	618	182	172.3	2.7			
300	800	618	182	166	0.0			

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@0.9pf)	Guaranteed WAE* Production (kWh)
60	818	618	200	199.4	54.7			
120	818	618	200	197.5	70.7			
180	818	618	200	194.5	12.0			
240	818	618	200	190.3	4.0			
300	818	618	200	184.9	4.0			
60	836	618	218	217.4	49.3			
120	836	618	218	215.5	62.7			
180	836	618	218	212.5	70.7			
240	836	618	218	208.3	56.0			
300	836	618	218	202.9	24.0			
60	854	618	236	235.4	169.3			
120	854	618	236	233.5	41.3			
180	854	618	236	230.5	41.3			
240	854	618	236	226.3	48.0			
300	854	618	236	220.9	74.4			
60	872	618	254	253.4	45.3			
120	872	618	254	251.5	29.3			
180	872	618	254	248.5	16.0			
240	872	618	254	244.3	45.3			
300	872	618	254	238.9	49.3			

Table 3.06.1 Combined Turbine-Generator Performance @0.9 pf (Base Bid)

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@1.0pf)	Guaranteed WAE* Production (kWh)
60	728	618	110	109.4	106.7			
120	728	618	110	107.5	198.7			
180	728	618	110	104.5	144.0			
240	728	618	110	100.3	81.3			
300	728	618	110	94.9	41.3			
60	756	618	128	127.4	116.0			
120	756	618	128	125.5	364.0			
180	756	618	128	122.5	118.7			
240	756	618	128	118.3	53.3			
300	756	618	128	112.9	41.3			
60	764	618	146	145.4	113.3			
120	764	618	146	143.5	344.0			
180	764	618	146	140.5	108.0			
240	764	618	146	136.3	38.7			
300	764	618	146	130.9	26.7			
60	782	618	164	163.4	92.0			
120	782	618	164	161.5	222.7			
180	782	618	164	158.5	49.3			
240	782	618	164	154.3	32.0			
300	782	618	164	148.9	18.7			
60	800	618	182	181.4	66.7			
120	800	618	182	179.5	96.0			
180	800	618	182	176.5	53.3			
240	800	618	182	172.3	2.7			
300	800	618	182	166	0.0			

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@1.0pf)	Guaranteed WAE* Production (kWh)
60	818	618	200	199.4	54.7			
120	818	618	200	197.5	70.7			
180	818	618	200	194.5	12.0			
240	818	618	200	190.3	4.0			
300	818	618	200	184.9	4.0			
60	836	618	218	217.4	49.3			
120	836	618	218	215.5	62.7			
180	836	618	218	212.5	70.7			
240	836	618	218	208.3	56.0			
300	836	618	218	202.9	24.0			
60	854	618	236	235.4	169.3			
120	854	618	236	233.5	41.3			
180	854	618	236	230.5	41.3			
240	854	618	236	226.3	48.0			
300	854	618	236	220.9	74.4			
60	872	618	254	253.4	45.3			
120	872	618	254	251.5	29.3			
180	872	618	254	248.5	16.0			
240	872	618	254	244.3	45.3			
300	872	618	254	238.9	49.3			

Table 1.06.2 Combined Turbine-Generator Performance @1.0 pf (Base Bid)

1.07 GUARANTEED CHARACTERISTICS – COMBINED TURBINE-GENERATOR (ALTERNATE BID)

A. Expected Performance.

Bidder shall provide all curves and tabulations of expected performance covering at a minimum, the range of 5 percent to maximum output over the full range of operating heads. Curves shall include the following:

1. The relationship between flow, head, efficiency, and power output (at generator terminals).
2. Percentage opening versus flow for wicket gate position 0% to 100%.
3. The curves shall cover the full range of operating heads based on Bidder's design and shall show the cavitation limits for the turbine.

B. The performance provided herein shall be based on acceptable operation, without objectionable or detrimental power surges, cavitation, or perceptible vibration within the specified performance envelope.

C. Guaranteed Turbine-Generator Output.

The turbine-generator is guaranteed to produce not less than ___________ kW at 0.9pf, measured at the generator terminals, without exceeding the turbine cavitation and generator temperature rise limits and operating at ______ rpm under a net head of the turbine design.

D. Guaranteed Turbine-Generator Peak Efficiency.

The point of maximum efficiency of the turbine-generator operating a rated speed, 1.0pf, is guaranteed to be not less than stated below:

1. Net Head: _______ ft.
2. Efficiency: _______ %.
3. Turbine-Generator Output: _________ kW at 1.0pf, measured at the generator terminals.

E. Guaranteed Turbine-Generator Efficiency.

The turbine-generator is guaranteed to have the efficiencies stated on the following pages without exceeding the turbine cavitation and generator temperature rise limits when operating at rated speed under the net heads and corresponding tailwater elevations indicated below and with water temperatures of 65°F.

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@0.9pf)	Guaranteed WAE* Production (kWh)
60	728	618	110	109.4	106.7			
120	728	618	110	107.5	198.7			
180	728	618	110	104.5	144.0			
240	728	618	110	100.3	81.3			
300	728	618	110	94.9	41.3			
60	756	618	128	127.4	116.0			
120	756	618	128	125.5	364.0			
180	756	618	128	122.5	118.7			
240	756	618	128	118.3	53.3			
300	756	618	128	112.9	41.3			
60	764	618	146	145.4	113.3			
120	764	618	146	143.5	344.0			
180	764	618	146	140.5	108.0			
240	764	618	146	136.3	38.7			
300	764	618	146	130.9	26.7			
60	782	618	164	163.4	92.0			
120	782	618	164	161.5	222.7			
180	782	618	164	158.5	49.3			
240	782	618	164	154.3	32.0			
300	782	618	164	148.9	18.7			
60	800	618	182	181.4	66.7			
120	800	618	182	179.5	96.0			
180	800	618	182	176.5	53.3			
240	800	618	182	172.3	2.7			
300	800	618	182	166	0.0			

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@0.9pf)	Guaranteed WAE* Production (kWh)
60	818	618	200	199.4	54.7			
120	818	618	200	197.5	70.7			
180	818	618	200	194.5	12.0			
240	818	618	200	190.3	4.0			
300	818	618	200	184.9	4.0			
60	836	618	218	217.4	49.3			
120	836	618	218	215.5	62.7			
180	836	618	218	212.5	70.7			
240	836	618	218	208.3	56.0			
300	836	618	218	202.9	24.0			
60	854	618	236	235.4	169.3			
120	854	618	236	233.5	41.3			
180	854	618	236	230.5	41.3			
240	854	618	236	226.3	48.0			
300	854	618	236	220.9	74.4			
60	872	618	254	253.4	45.3			
120	872	618	254	251.5	29.3			
180	872	618	254	248.5	16.0			
240	872	618	254	244.3	45.3			
300	872	618	254	238.9	49.3			

Table 1.07.1 Combined Turbine-Generator Performance @0.9 pf (Alternate Bid _____rpm)

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@1.0pf)	Guaranteed WAE* Production (kWh)
60	728	618	110	109.4	106.7			
120	728	618	110	107.5	198.7			
180	728	618	110	104.5	144.0			
240	728	618	110	100.3	81.3			
300	728	618	110	94.9	41.3			
60	756	618	128	127.4	116.0			
120	756	618	128	125.5	364.0			
180	756	618	128	122.5	118.7			
240	756	618	128	118.3	53.3			
300	756	618	128	112.9	41.3			
60	764	618	146	145.4	113.3			
120	764	618	146	143.5	344.0			
180	764	618	146	140.5	108.0			
240	764	618	146	136.3	38.7			
300	764	618	146	130.9	26.7			
60	782	618	164	163.4	92.0			
120	782	618	164	161.5	222.7			
180	782	618	164	158.5	49.3			
240	782	618	164	154.3	32.0			
300	782	618	164	148.9	18.7			
60	800	618	182	181.4	66.7			
120	800	618	182	179.5	96.0			
180	800	618	182	176.5	53.3			
240	800	618	182	172.3	2.7			
300	800	618	182	166	0.0			

Turbine Discharge (cfs)	Headwater Elevation (ft)	Tailwater Elevation (ft)	Gross Head (ft)	Net Head (ft)	Weighting Factor (HRS)	Turb-Gen Efficiency (%)	Turb-Gen Output (kW@1.0pf)	Guaranteed WAE* Production (kWh)
60	818	618	200	199.4	54.7			
120	818	618	200	197.5	70.7			
180	818	618	200	194.5	12.0			
240	818	618	200	190.3	4.0			
300	818	618	200	184.9	4.0			
60	836	618	218	217.4	49.3			
120	836	618	218	215.5	62.7			
180	836	618	218	212.5	70.7			
240	836	618	218	208.3	56.0			
300	836	618	218	202.9	24.0			
60	854	618	236	235.4	169.3			
120	854	618	236	233.5	41.3			
180	854	618	236	230.5	41.3			
240	854	618	236	226.3	48.0			
300	854	618	236	220.9	74.4			
60	872	618	254	253.4	45.3			
120	872	618	254	251.5	29.3			
180	872	618	254	248.5	16.0			
240	872	618	254	244.3	45.3			
300	872	618	254	238.9	49.3			

Table 1.07.2 Combined Turbine-Generator Performance @1.0 pf (Alternate Bid _____rpm)

ATTACHMENT C – TECHNICAL DATA

1.08 TURBINE DATA – FRANCIS TURBINE

A. Manufacturer:

____

(Name)

B. Homologous Turbine.

1. The proposed turbine runner is homologous to the following:

   a. A scale model tested at:

      (1) ____(place)

      (2) ____(year)

   b. A turbine field tested at:

      (1) ____(place)

      (2) ____(year)

   c. Designed for a rated output of _______________________________kW.

   d. Under a rated head of _____________________________________ft.

   e. At a rated speed of ____rpm.

2. Prototype turbine efficiency calculated from the corresponding homologous model efficiencies can be scaled up by not more than 2/3 of the efficiency step-up determined by the Moody formula in which the losses are assumed to be inversely proportional to the 1/5 power of the runner diameter. The efficiency step-up shall be calculated form the peak of the model turbine efficiency-hill curve. The step-up value shall be added uniformly as as a constant increment (in percentage points) to all values of model turbine efficiency to obtain the corresponding prototype efficiencies. Contractor shall make efficiency adjustments for dimensional differences between the model and prototype which exceed the requirements of homology in accordance with IEC 60193, Model Acceptance Tests of Hydraulic Turbines and provide documentation and justification for any and all such adjustment with their proposal.

C. Basis of Design – See Attachment D.

D. Drawings and Information

1. Drawing of turbine showing principal parts and dimensions and overall arrangement of the proposed turbine. Include plan, elevation and cross sectional views of the turbine. Show block outs to illustrate areas for first, second, and third stage concrete.
2. Drawing of turbine runner and shaft showing principal parts and dimensions and arrangement blade servomotor mechanism and other internal parts.

E. Runner Characteristics and Data.

1. Runner Diameter (discharge ring at centerline of blades) _______________inches
2. Runner Assembled Weight ____pounds
3. Runner and Shaft WR^2 ____$lb\text{-}ft^2$
4. Minimum Gate for Guaranteed Continuous Operation _________________
5. Number of Runner Blades ____
6. Blade Material ____
7. Hub Material____
8. Number of Wicket Gates ____
9. Wicket Gate Material ____
10. Describe runner design and construction

____

____

____

____

____

11. Describe runner nondestructive testing.

____

____

____

12. Describe wicket gate design and construction.

13. Describe wicket gate mechanism design and construction.

14. Describe turbine shaft seal design and construction

15. Describe all applicable turbine Bearing design, type and construction

16. Describe method of spiral case embedment and any special design requirements for the powerhouse structure to accommodate the spiral case design and method of embedment. Note if field welding of the spiral case is required in order to accommodate size restrictions for shipping and/or installation.

1.09 GENERATOR DATA

A. Manufacturer:

(Name)

B. Drawings and Information.

1. Drawing of unit cross section showing the principal parts of the generator.

C. Information.

1. Description of stator coil construction, insulation, and VPI process.

____

2. Description of core material.

____

____

D. Generator Characteristics and Data.

1. Max Output Rating @ 0.9 pf ____kW
2. Voltage, stator (phase-to-phase) _____________________________________
3. Amperages, stator (full load) ____
4. Voltage, field ____
5. Amperages, field (full load) ____
6. Rotor and Shaft WR^2 ____$lb\text{-}ft^2$
7. Weight of Stator ____lbs
8. Weight of Rotor ____lbs
9. Diameter of Stator Core ____inches
10. Diameter of Rotor ____inches
11. Type of Housing ____
12. Stator Insulation NEMA Class_______________________________________
13. Stator Temp Rise @ 40°C Ambient __________________________________°C
14. Field Insulation NEMA Class _______________________________________
15. Field Temp Rise @ 40°C Ambient ___________________________________°C
16. Short Circuit Ratio ____
17. Direct Axis Synchronous Reactance (Xd) ____________________________pu
18. Direct Axis Transient Reactance (Xd) _______________________________pu
19. Direct Axis Subtransient Reactance (Xd'') ___________________________pu
20. Zero Sequence Reactance (Xo) ____________________________________pu

E. Stator Winding Characteristics

1. Coil Construction (multi-turn, bar, etc.) ______________________________

2. Strand transposition method ____
3. Number of turns for each coil ____
4. Number of parallel paths ____
5. Coil pitch ____
6. Number of stator slots ____

F. Stator Air Cooler Data.

1. Number of Coolers ____

G. Generator Bearings.

1. Total load capacity of thrust bearing ________________________________lbs.

H. Partial discharge analysis system coupler manufacturer and type________________

____

1.10 TURBINE SHUTOFF VALVE

A. Manufacturer:

____

(Name)

B. Drawings and Information.

1. Drawing of valve showing basic dimensions, type of construction and arrangement of servomotor and counterweight mechanism.
2. Type of bypass valve (needle or other).

C. Valve Characteristics and Data

1. Valve diameter ____inches
2. Valve assembled weight ____lbs.

D. Information.

1. Describe valve and servomotor design and construction.

____

____

2. Describe valve design and construction.

____

____

1.11 GOVERNOR DATA

A. Governor Characteristics and Data.

1. Mechanical start time (T_m) ____sec.

B. Information.

1. Attach descriptive literature of proposed governor system.

C. Governor Electronic Control System Characteristics

1. PLC manufacturer & model ____
2. Software manufacturer and type ______________________________________

D. Governor Power Unit Characteristics.

1. Main pump rating ____hp
2. Standby pump rating ____hp
3. Wicket gate opening time ____sec.
4. Wicket gate closing time ____sec.

1.12 EXCITER DATA

A. Excitation System Characteristics.

1. Exciter manufacturer & model____
2. Voltage regulator characteristics (steady state)
   a. Voltage range ____%
   b. Voltage regulation ____%

1.13 AUTOMATION

A. PLC System Characteristics.

1. PLC Manufacturer ____
2. PLC Model ____
3. PLC Programming Software Manufacturer and Type ________________________

   ____

B. Human-Machine Interface (HMI) System Characteristics.

1. Control Room PC.
   a. Manufacturer and model ______________________________________
   b. Display Manufacturer & Model ________________________________
2. Turbine-Generator Switchboard HMI Touchscreen.
   a. Manufacturer and model ______________________________________
   b. Touch Screen size & type ____________________________________

C. Turbine – Generator Control Switchboard Characteristics.

1. Generator protection relay manufacturer and model _______________________

   ____
2. Transformer and overhead line protection relay manufacturer & model __________

   ____
3. Lock-out relay manufacturer and model __________________________________

   ____

D. Uninterruptible Power Supply (UPS) Manufacturer and Characteristics.

1. Manufacturer & model ____
2. Output Voltage ____
3. Output capacity ____
4. Battery backup time ____

E. Generator Circuit Breaker and Switchgear

1. Manufacturer ____

2. Model ____

3. Rated Current ____

4. Rated Voltage ____

5. Rated Short Circuit parameters ____

6. MAJOR EQUIPMENT SUPPLIERS AND PLAT LOCATIONS

	Item	Manufacturer's Name	Location of Manufacturer
1	Wicket Gate Castings		
2	Runner Blade Castings/Forgings		
3	Runner Hub Castings		
4	Turbine Shaft Forging		
5	Shaft Seal		
6	Spiral Case & Stay Ring		
7	Headcover		
8	Bottom Ring and Discharge Ring		
9	Draft Tube Liner		
10	Turbine Shop Assembly		
11	Turbine Shutoff Valve		
12	Generator Shaft Forging		
13	Rotor Spider		
14	Stator Frame		
15	Generator Guide Bearings		
16	Generator Thrust Bearing		
17	Generator Shop Assembly		
18	Turbine-Generator Control Switchboard		
19	Exciter		
20	Turbine Governor		
21	Governor/TSV HPU		
22	Generator Circuit Breaker and Switchgear		

ATTACHMENT D – BASIS OF DESIGN

Append information describing the hydraulic and mechanical Basis of Design for the turbine. Submit information that the performance and operation characteristics, both guaranteed and expected, of the turbine(s) proposed by the Bidder are based upon data derived from prior model tests, CFD analysis, and/or the tested field performance of comparable turbines of the manufacturer's own design. Describe how performance guarantees were derived and the degree to which CFD analysis has or will be used to complete the hydraulic design.

Describe the type of design and analytical tools (e.g., finite element, fatigue, fracture mechanics, analytical computations) and the extent to which these tools have or will be used in the mechanical design of the turbine. Indicate which parts of the turbine have or will be designed for this specific project based on finite element, fatigue, fracture mechanics or other analysis. Indicate which parts of the turbine are standard or pre-engineered based on previous projects. Indicate any outsourcing of specialty services in terms of finite element analyses or other engineering-related tasks for completing the overall turbine design.

ATTACHMENT E – LIST OF SUB-SUPPLIERS

Append Bidder's list of major sub-suppliers proposed for the Work for approval by the Owner. Provide the names, locations, and indicate the type of work. Indicate any outsourcing of specialty services such as nondestructive testing or firms specializing in finite element analyses or other engineering-related tasks. Bidder shall show that each major sub-supplier's experience meets the minimum requirements of the Contract for their proposed scope of work for this Project.

ATTACHMENT F – PRELIMINARY PROGRESS SCHEDULE

Append Bidder's Preliminary Progress Schedule showing the following:

A. Major milestone dates for design and submittals.

B. Major milestone dates for sourcing long-lead time materials and/or equipment.

C. Major milestone dates for manufacture.

D. Major milestone dates for shop assembly and factory testing.

E. Major milestone dates for shipments and deliveries.

ATTACHMENT G – ALTERNATIVES

The Owner intends to procure turbine-generator equipment of high performance and high quality at the most reasonable price. The bidding Documents have been set up to allow Bidder's to offer a unit speed different than that specified for the Base Bid, so as to compare the cost of the units, together with their relative merits in terms of performance, efficiency, and other pertinent factors prior to award. For bidding purposes the Base Bid assumes a unit speed of 400 rpm, whereas the alternate Bid allows for an alternate unit speed that may be preferred or recommended by the Bidder. In addition, if Bidder's "standard" design differs from that specified herein and savings may be realized without sacrificing performance and quality, the Owner will consider the alternatives as part of the Proposal evaluation process. The Owner will also consider alternative designs and materials, where Bidder can present experience, performance data and other pertinent details to demonstrate that the alternative is equal to or better in function, performance, quality and/or more cost effective than that specified. Append sufficient details and pricing adjustments, if any, for each alternative to be considered by the Owner.

ATTACHMENT H – LOAD LIST FOR ESTIMATED LOAD CONSUMPTION

Provide estimated load requirements for all the equipment within the supply scope. Provide a table for all the possible voltage requirements- 480VAC, 120VAC, 125VDC and 24VDC.

ATTACHMENT I – EXCEPTIONS AND CLARIFICATIONS

Any Exceptions and Clarifications by the bidder shall be listed in this section. Each exception and clarification shall be marked clearly and listed in numerical order. Example- Exception-1 "XXXXX", Clarification-1 "XXXXXX" and so forth.

ATTACHMENT J – MAJOR ASSUMPTIONS

Supplier to submit this section, if applicable. No specific format is required.

ATTACHMENT K – PROPRIETARY DESIGN

Supplier to submit this section, if applicable. No specific format is required.

ATTACHMENT L – O&M DATA AND COSTS

Supplier to submit this section. No specific format is required.

FORM
OF
AGREEMENT BETWEEN
BUYER AND SELLER
FOR
PINE FLAT UNIT-4 PROJECT
WATER TO WIRE EQUIPMENT PACKAGE PROCUREMENT

TABLE OF ARTICLES

AGREEMENT

THIS AGREEMENT is between (“Buyer”) and ____ ____ (“Seller”).

Buyer and Seller, in consideration of the mutual covenants set forth herein, agree as follows:

ARTICLE 1 - GOODS AND SPECIAL SERVICES

1.01 Seller shall furnish the Goods and Special Services as specified or indicated in the Contract Documents. The Goods and Special Services to be furnished are described in Section 01010, Summary of Work.

ARTICLE 2 - THE PROJECT

2.01 The Project for which the Goods and Special Services to be provided under the Contract Documents may be the whole or only a part is generally described as follows:

Tulloch 3rd Unit Addition, Turbine-Generator Procurement Contract

ARTICLE 3 - ENGINEER

3.01 The Contract Documents for the Goods and Special Services have been prepared by the buyer and Stantec Consulting Services, Inc.

who is hereinafter called Engineer and who is to assume all duties and responsibilities, and have the rights and authority assigned to Engineer in the Contract Documents in connection with the furnishing of Goods and Special Services.

ARTICLE 4 - POINT OF DESTINATION

4.01 The place where the Goods are to be delivered is defined in the General Conditions as the Point of Destination and is designated as:

Pine Flat Hydroelectric Power Plant, 27709 Pine Flat Road, Piedra, California 93649
Fresno County

Contact at the plant: Eduardo Blanco,
Designation: Buyer
Telephone: (559) 787-2577, Ext-204 OR (559) 978-3025

ARTICLE 5 - CONTRACT TIMES

5.01 *Time of the Essence*

A. All time limits for Milestones, if any, the delivery of Goods and the furnishing of Special Services as stated in the Contract Documents are of the essence of the Contract.

5.02 *Days for Submittal of Shop Drawings*

A. An initial Preliminary Design Drawings submittal, containing confirmed equipment dimensions and locations shall be submitted 30-days after NTP. The dimensions and information shall be of sufficient detail to allow design of the powerhouse structure to proceed.

B. All Shop Drawings and Samples required by the Contract Documents will be submitted to Buyer for Engineer's review and approval within 120 days after the date when the Contract Times commence to run as provided in Paragraph 2.03 of the General Conditions.

5.03 *Days to Achieve Delivery of Goods*

A. The Goods are to be delivered to the Point of Destination and ready for Buyer's receipt of delivery on (or within a period of 15 days prior to) the following three periods of elapsed dates:

a. first stage embedded parts, 9 months after NTP
b. second stage embedded parts, 12 months after NTP
c. remainder of turbine and generator, 16 months after NTP.

5.04 *Days for Furnishing Special Services*

A. The furnishing of Special Services to Buyer will commence within 15 days after Buyer's written notice to Seller following Buyer's receipt of delivery of the Goods, and shall be completed within 365 days thereafter. Such notice will be given no later than 5 days after Buyer's receipt of delivery.

5.05 *Liquidated Damages*

A. Buyer and Seller recognize that time is of the essence of this Agreement and that Buyer will suffer financial loss if the Goods are not delivered at the Point of Destination and ready for receipt of delivery by Buyer within the times specified in Paragraphs 5.02 and 5.03 above, plus any extensions thereof allowed in accordance with Article 7 of the General Conditions. The parties also recognize that the timely performance of services by others involved in the Project are materially dependent upon Seller's specific compliance with the requirements of Paragraphs 5.02 and 5.03. Further, they recognize the delays, expense and difficulties involved in proving the actual loss suffered by Buyer if complete acceptable Goods are not delivered on time. Accordingly, instead of requiring such proof, Buyer and Seller agree that as liquidated damages for delay (but not as a penalty) Seller shall pay Buyer $ 1,000.00 (US dollars One Thousand and zero cents) or each day that expires after the time specified in Paragraph 5.03 for delivery of acceptable Goods.

ARTICLE 6 - CONTRACT PRICE

6.01 Buyer shall pay Seller for furnishing the Goods and Special Services in accordance with the Contract Documents in current United States funds as follows:

A. The prices stated in Seller's completed Bid Form, attached hereto as an exhibit.

ARTICLE 7 - PAYMENT PROCEDURES

7.01 *Submittal and Processing of Payments.*

A. Seller shall submit Applications for Payment in accordance with Article 10 of the General Conditions. Applications for Payment will be processed by buyer upon verification by the engineer as provided in the General Conditions.

7.02 *Progress Payments.*

A. Buyer shall make progress payments on account of the Contract Price on the basis of Seller's Applications for Payment as follows:

1. Upon receipt of an Application for Payment submitted in accordance with Paragraph 10.01.A.1 of the General Conditions and accompanied by Engineer's recommendation of payment in accordance with Paragraph 10.02.A of the General Conditions, the following amounts, as a percentage of the Contract Price, less such amounts as Engineer may determine in accordance with Paragraph 10.02.A.3 of the General Conditions:

At Contract Award	10%
Submittals	20%
Equipment Ship	30%
Equipment Received	30%
Special Service Complete	10%

7.03 *Retention Amount*
An amount equal to 5% of each Progress Payment request shall be retained by the Owner. The retention shall be paid by Owner following Actual Full Operation Date, as defined in the Supplementary Conditions, Article 15.

7.04 *Final Payment*

A. Upon receipt of the final Application for Payment accompanied by Engineer's recommendation of payment in accordance with Paragraph 10.06 of the General Conditions, Buyer shall pay the remainder of the Contract Price as recommended by Engineer.

ARTICLE 8 - INTEREST

8.01 All monies not paid when due as provided in Article 10 of the General Conditions shall bear interest at the rate of 5 percent per annum.

ARTICLE 9 - SELLER'S REPRESENTATIONS

9.01 In order to induce Buyer to enter into this Agreement, Seller makes the following representations:

A. Seller has examined and carefully studied the Contract Documents and the other related data identified in the Bidding Documents.

B. If specified or if, in Seller's judgment, any local condition may affect cost, progress or the furnishing of the Goods and Special Services, Seller has visited the Point of Destination and become familiar with and is satisfied as to the local conditions that may affect cost, progress or the furnishing of the Goods and Special Services.

C. Seller is familiar with and is satisfied as to all local federal, state and local Laws and Regulations that may affect cost, progress and the furnishing of the Goods and Special Services.

D. Seller has carefully studied and correlated the information known to Seller, and information and observations obtained from Seller's visits, if any, to the Point of Destination, with the Contract Documents.

E. Seller has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Seller has discovered in the Contract Documents, and the written resolution thereof by Engineer is acceptable to Seller.

F. The Contract Documents are generally sufficient to indicate and convey understanding of all terms and conditions for furnishing Goods and Special Services.

ARTICLE 10 - CONTRACT DOCUMENTS

10.01 *Contents*

A. The Contract Documents consist of the following:

1. This Agreement (pages 1 to __, inclusive);

2. Performance Bond (pages __ to __, inclusive);

3. Other bonds

   a. _Bid Bond____________________ (pages ___ to ___, inclusive);

   b. _Payment Bond____________________ (pages ___ to ___, inclusive);

4. General Conditions (pages ___ to ___, inclusive);

5. Supplementary Conditions (pages ___ to ___, inclusive);

6. Specifications as listed in table of contents of the Project Manual dated ___________;

7. Drawings, consisting of a cover sheet and sheets numbered _______ through _______, inclusive, with each sheet bearing the following general title:

8. Addenda (Numbers ____ to ____, inclusive);

9. Exhibits to this Agreement (enumerated as follows):

   a. Seller's Bid (pages ___ to ___, inclusive);

   b. Documentation submitted by Seller prior to Notice of Award (pages __ to __, inclusive);

   c. ____;

10. The following which may be delivered or issued on or after the Effective Date of the Agreement and are not attached hereto:

   a. Notice to Proceed (pages ___ to ___, inclusive);

   b. Written Amendment(s);

   c. Change Order(s);

   d. Field Order(s);

   e. Engineer's Written Interpretation(s).

B. The documents listed in paragraph 10.01.A are attached to this Agreement (except as expressly noted otherwise above).

C. There are no Contract Documents other than those listed above in this Article 10.

D. The Contract Documents may only be amended, or supplemented as provided in Paragraph 3.04 of the General Conditions.

ARTICLE 11 - MISCELLANEOUS

11.01 *Defined Terms*

A. Terms used in this Agreement will have the meanings indicated in the General Conditions and the Supplementary Conditions.

11.02 *Assignment*

A. No assignment by a party hereto of any rights under or interests in the Contract Documents will be binding on another party hereto without the written consent of the party sought to be bound. Specifically but without limitation, moneys that may become due and moneys that are due may not be assigned without such consent (except to the extent that the effect of this restriction may be limited by law). Unless specifically stated to the contrary in any written consent to an assignment, no assignment will release or discharge the assignor from any duty or responsibility under the Contract Documents.

11.03 *Successors and Assigns*

A. Buyer and Seller each binds itself, its partners, successors, assigns and legal representatives to the other party hereto, its partners, successors, assigns and legal representatives in respect to all covenants, agreements and obligations contained in the Contract Documents.

11.04 *Severability*

A. Any provision or part of the Contract Documents held to be void or unenforceable under any Law or Regulation shall be deemed stricken, and all remaining provisions shall continue to be valid and binding upon Buyer and Seller. The Contract Documents shall be reformed to replace such stricken provision or part thereof with a valid and enforceable provision that comes as close as possible to expressing the intention of the stricken provision.

IN WITNESS WHEREOF, Buyer and Seller have signed this Agreement in duplicate. One counterpart each has been delivered to Buyer and Seller. All portions of the Contract Documents have been signed or identified by Buyer and Seller or on their behalf.

This Agreement will be effective on *[insert date]*.

Buyer: ______________________	Seller: ______________________
By: ______________________ [Corporate Seal]	By: ______________________ [Corporate Seal]
Attest: ______________________	Attest: ______________________
Address for giving notice: ______________________ ______________________ ______________________	Address for giving notice: ______________________ ______________________ ______________________
(If Buyer is a corporation, attach evidence of authority to sign. If Buyer is a public body, attach evidence of authority to sign and resolution or other documents authorizing execution of Buyer-Seller Agreement.)	Agent for service of process: ______________________ ______________________ ______________________ (If Seller is a corporation or a partnership, attach evidence of authority to sign.)
Designated Representative:	Designated Representative:
Name: ______________________	Name: ______________________
Title: ______________________	Title: ______________________
Address: ______________________	Address: ______________________
Phone: ______________________	Phone: ______________________
Facsimile: ______________________	Facsimile: ______________________

GENERAL CONDITIONS

TABLE OF CONTENTS

GENERAL CONDITIONS FOR PROCUREMENT CONTRACTS

ARTICLE 1 – DEFINITIONS AND TERMINOLOGY

1.01 Defined Terms

A. Whenever used in the Bidding Requirements or Contract Documents and printed with initial capital letters, the terms listed below will have the meanings indicated which are applicable to the singular or plural thereof. In addition to terms specifically defined, terms with initial capital letters in the Contract Documents include references to identified articles and paragraphs, and the titles of other documents or forms.

1. *Addenda*--Those written or graphic instruments issued prior to the opening of Bids in accordance with the Bidding Requirements which clarify or change the Bidding Requirements or the proposed Contract Documents.

2. *Agreement*--The written instrument signed by both Buyer and Seller covering the Goods and Special Services and which lists the Contract Documents in existence on the Effective Date of the Agreement.

3. *Application for Payment*--The form acceptable to Buyer which is used by Seller in requesting progress and final payments and which is accompanied by such supporting documentation as is required by the Contract Documents.

4. *Bid*--An offer or proposal submitted on the prescribed form setting forth the prices for the Goods and Special Services to be provided.

5. *Bidder*--A person who submits a Bid directly to Buyer.

6. *Bidding Documents*--The Bidding Requirements and the proposed Contract Documents (including all Addenda).

7. *Bidding Requirements*--The Advertisement or Invitation to Bid, Instructions to Bidders, Form of Bid security, if any, and Bid Form with any supplements.

8. *Buyer*--The person or public entity purchasing the Goods and Special Services.

9. *Change Order*--A document recommended by Engineer which is signed by Seller and Buyer and authorizes an addition, deletion, or revision to the Contract Documents or an adjustment in the Contract Price or the Contract Times, issued on or after the Effective Date of the Agreement.

10. *Claim*--A written demand or assertion by Buyer or Seller seeking an adjustment of Contract Price or Contract Times, or both, or other relief with respect to the terms of the Contract.

11. *Contract*--The entire and integrated written agreement between Buyer and Seller concerning the Goods and Special Services. The Contract supersedes prior negotiations, representations, or agreements, whether written or oral.

12. *Contract Documents*--Those items listed in the Agreement. Only printed or hard copies of the items listed in the Agreement are Contract Documents. Files in electronic media format of text, data, graphics, and the like are not Contract Documents, and may not be relied on by Seller. Approved Shop Drawings and other Seller's submittals are not Contract Documents.

13. *Contract Price*-- The moneys payable by Buyer to Seller for furnishing the Goods and Special Services in accordance with the Contract Documents as stated in the Agreement.

14. *Contract Times*--The times stated in the Agreement by which the Goods must be delivered and Special Services must be furnished.

15. *Drawings*--That part of the Contract Documents prepared or approved by Engineer which graphically shows the scope, intent, and character of the Goods and Special Services to be furnished by Seller.

16. *Effective Date of the Agreement*--The date indicated in the Agreement on which it becomes effective, but if no such date is indicated, it means the date on which the Agreement is signed and delivered by the last of the two parties to sign and deliver.

17. *Engineer*--The person designated as such in the Agreement.

18. *Field Order*--A written order issued by Engineer which requires minor changes in the Goods or Special Services but which does not involve a change in the Contract Price or Contract Times.

19. *General Requirements*--Sections of Division 1 of the Specifications. The General Requirements pertain to all sections of the Specifications.

20. *Goods*--The tangible and movable personal property that is described in the Contract Documents, regardless of whether the property is to be later attached to realty.

21. *Laws and Regulations; Laws or Regulations*--Any and all applicable laws, rules, regulations, ordinances, codes, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.

22. *Milestone*--A principal event specified in the Contract Documents relating to an intermediate completion date or time prior to the Contract Times.

23. *Notice of Award*--The written notice by Buyer to the apparent Successful Bidder stating that upon timely compliance by the apparent Successful Bidder with the conditions precedent listed therein, Buyer will sign and deliver the Agreement.

24. *Notice to Proceed*-- A written notice given by Buyer to Seller fixing the date on which the Contract Times commence to run and on which Seller shall start to perform under the Contract.

25. *Point of Destination* --The specific address of the location where delivery of the Goods shall be made as stated in the Agreement.

26. *Project*--The total undertaking of which the Goods and Special Services to be provided under the Contract are a part.

27. *Project Manual*--The bound documentary information prepared for bidding and furnishing the Goods and Special Services. A listing of the contents of the Project Manual, which may be bound in one or more volumes, is contained in the table(s) of contents.

28. *Samples*--Physical examples of materials, equipment, or workmanship that are representative of some portion of the Goods and which establish the standards by which such portion of the Goods or Special Services will be judged.

29. *Seller*--The person furnishing the Goods and Special Services.

30. *Shop Drawings*--All drawings, diagrams, illustrations, schedules, and other data or information which are specifically prepared or assembled by or for Seller and submitted by Seller to illustrate some portion of the Goods or Special Services.

31. *Special Services*--Services associated with the Goods to be furnished by Seller as required by the Contract Documents.

32. *Specifications*--That part of the Contract Documents consisting of written technical descriptions of materials, equipment, systems, standards and workmanship as applied to the furnishing of the Goods and Special Services, and certain administrative details applicable thereto.

33. *Successful Bidder*--The lowest responsible Bidder submitting a responsive Bid, to whom Buyer makes an award.

34. *Supplementary Conditions*--That part of the Contract Documents which amends or supplements these General Conditions.

35. *Written Amendment*--A written statement modifying the Contract Documents, signed by Buyer and Seller on or after the Effective Date of the Agreement and normally dealing with the administrative aspects of the Contract Documents.

1.02 Terminology

A. *Intent of Certain Terms or Adjectives*

1. The Contract Documents include the terms “as allowed,” “as approved,” “as ordered,” “as directed” or terms of like effect or import to authorize an exercise of professional judgment by Engineer. In addition, the adjectives “reasonable,” “suitable,” “acceptable,” “proper,” “satisfactory,” or adjectives of like effect or import are used to describe an action or determination of Engineer as to the Goods or Special Services. It is intended that such exercise of professional judgment, action or determination will be solely to evaluate, in general, the Goods or Special Services for compliance with the requirements of and information in the Contract Documents and conformance with the design concept of the completed Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective shall not be effective to assign to Engineer any duty or authority to supervise or direct the furnishing of Goods or Special Services or any duty or authority to undertake responsibility contrary to any other provision of the Contract Documents.

2. Unless stated otherwise in the Contract Documents, words or phrases which have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

3. The word “non-conforming” when modifying the words “Goods” or “Special Services”, refers to Goods or Special Services that fail to conform to the Contract Documents.

4. The word “receipt” when referring to the Goods, shall mean the physical taking and possession by the Buyer under the conditions specified in Paragraph 8.01.B.3.

B. *Day*

1. The word “day” shall constitute a calendar day of 24 hours measured from midnight to the next midnight.

ARTICLE 2 - PRELIMINARY MATTERS

2.01 *Delivery of Bonds*

A. When Seller delivers the executed Agreements to Buyer, Seller also shall deliver such bonds as Seller may be required to furnish.

2.02 Copies of Documents

A. Buyer shall furnish Seller an electronic copy of the Contract Documents. Contract Documents shall be signed by both parties using DocuSign. Printed copies will be furnished upon request at the cost of reproduction.

2.03 *Commencement* of Contract Times; Notice to Proceed

A. The Contract Times will commence to run on the thirtieth day after the Effective Date of the Agreement or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Agreement. In no event will the Contract Times commence to run later than the sixtieth day after the day of Bid opening or the thirtieth day after the Effective Date of the Agreement, whichever date is earlier.

2.04 *Designated* Representatives

A. Buyer and Seller shall each designate its representative at the time the Agreement is signed. Each representative shall have full authority to act on behalf of and make binding decisions in any matter arising out of or relating to the Contract.

2.05 Before Starting Fabrication/Assembly of Goods

A. *Seller's Review of Contract Documents:* Before commencing performance of the Contract, Seller shall carefully study and compare the Contract Documents and check and verify pertinent requirements therein and, if specified, all applicable field measurements. Seller shall promptly report in writing to Buyer and Engineer any conflict, error, ambiguity or discrepancy which Seller may discover and shall obtain a written interpretation or clarification from Engineer before proceeding with any work affected thereby.

2.06 Progress Schedule

A. Within 15 days after the Contract Times start to run, Seller shall submit to Buyer and Engineer an acceptable progress schedule of activities, including at a minimum, Shop Drawing and Sample submittals, tests, and deliveries as required by the Contract Documents. No progress payment will be made to Seller until an acceptable schedule is submitted to Buyer and Engineer.

B. The progress schedule will be acceptable to Buyer and Engineer if it provides an orderly progression of the submittals, tests, and deliveries to completion within the specified Milestones and the Contract Times. Such acceptance will not impose on Buyer or Engineer responsibility for the progress schedule, for sequencing, scheduling, or progress of the work nor interfere with or relieve Seller from Seller's full responsibility therefor. Such acceptance shall not be deemed to acknowledge the reasonableness and attainability of the schedule.

2.07 *Preliminary* Conference/ Kick-off meeting

A. Within 20 days after the Contract Times start to run, a conference attended by Seller, Buyer, Engineer and others as appropriate will be held to establish a working understanding among the parties as to the Goods and Special Services and to discuss the schedule referred to in Paragraph 2.06.A., procedures for handling Shop Drawings and other submittals, processing Applications for Payment, and maintaining required records. The conference shall be attended in person by the key people of all the parties. A provision shall be made for video conference for those unable to attend in person. Location shall be Kings River Conservation District office at address 4886 E. Jensen Avenue, Fresno, CA 93725. A full 8 hour day and a full 8 hour backup day shall be set aside for the meeting. The location is subject to change.

ARTICLE 3 - CONTRACT DOCUMENTS: INTENT AND AMENDING

3.01 Intent

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. Any labor, documentation, services, materials, or equipment that may reasonably be inferred from the Contract Documents or from prevailing custom or trade usage as being required to produce the intended result will be provided, whether or not specifically called for, at no additional cost to Buyer.

C. Clarifications and interpretations of, or notifications of minor variations and deviations in, the Contract Documents, will be issued by Engineer as provided in Article 9.

3.02 Laws and Regulations, Standards, Specifications and Codes

A. Reference to standards, specifications, manuals, or codes of any technical society, organization, or association, or to Laws and Regulations, whether such reference be specific or by implication, shall mean the standard, specification, manual, code, or Laws and Regulations in effect at the time of opening of Bids (or on the Effective Date of the Agreement if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.

B. No provision of any such standard, specification, manual or code, or any instruction of a supplier shall be effective to change the duties or responsibilities of Buyer or Engineer, or any of their subcontractors, consultants, agents, or employees from those set forth in the Contract Documents, nor shall any such provision or instruction be effective to assign to Buyer or Engineer, or any of their consultants, agents, or employees any duty or authority to supervise or direct the performance of Seller's obligations or any duty or authority to undertake responsibility inconsistent with the provisions of the Contract Documents.

3.03 Reporting and Resolving Discrepancies

A. *Reporting Discrepancies:* If, during the performance of the Contract, Seller discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents or between the Contract Documents and any provision of any Law or Regulation applicable to the performance of the Contract or of any standard, specification, manual or code, or of any instruction of any supplier, Seller shall promptly report it to Buyer in writing for Buyer's and Engineer's review. Seller shall not proceed with the furnishing of the Goods or Special Services affected thereby until an amendment to or clarification of the Contract Documents has been issued. Seller shall not be liable to Buyer or Engineer for failure to report any such conflict, error, ambiguity, or discrepancy unless Seller knew or reasonably should have known thereof.

B. *Resolving Discrepancies:* Except as may be otherwise specifically stated in the Contract Documents, the provisions of the Contract Documents shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between the provisions of the Contract Documents and:

1. the provisions of any standard, specification, manual, code, or instruction (whether or not specifically incorporated by reference in the Contract Documents); or

2. the provisions of any Laws or Regulations applicable to the furnishing of the Goods and Special Services (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 Amending and Clarifying Contract Documents

A. The Contract Documents may be amended to provide for additions, deletions, and revisions to the Goods or Special Services or to modify the terms and conditions thereof by a Written Amendment or a Change Order.

B. The requirements of the Contract Documents may be supplemented, and minor variations and deviations in the Goods or Special Services not affecting Contract Price or Contract Times may be authorized, by one or more of the following ways: 1) a Field Order; 2) Engineer's approval of a Shop Drawing pursuant to Paragraph 5.06.D.2; or 3) Engineer's written interpretation or clarification.

ARTICLE 4 - BONDS AND INSURANCE

4.01 Bonds

A. Seller shall furnish performance and payment bonds, each in an amount at least equal to the Contract Price, to Buyer. The bonds shall be delivered in accordance with Paragraph 2.01 and shall remain in effect at least one year after the date final payment is due, except as provided otherwise by Laws or Regulations.

B. The bonds shall be issued in the form prescribed by the Contract Documents except as provided otherwise by Laws or Regulations and shall be executed by a surety named in the current list of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Circular 570 by the Financial Management Service, Surety Bond Branch, U.S. Department of the Treasury. Bonds signed by an agent must be accompanied by a certified copy of such agent's authority to act.

C. If the surety on a bond is declared bankrupt or becomes insolvent or its right to do business is terminated in the state where the Project is located or it ceases to meet the requirements of Paragraph 4.01.B, Seller shall provide another bond and surety which comply with those requirements within 20 days, at Seller's expense.

4.02 Insurance

A. Seller shall provide insurance of the types and coverages and in the amounts stipulated in the Supplementary Conditions.

ARTICLE 5 - SELLER'S RESPONSIBILITIES

5.01 Supervision and Superintendence

A. Seller shall be solely responsible for the means, methods, techniques, sequences, and procedures used in performing its obligations. Seller shall be responsible to see that the completed Goods and Special Services conform to the Contract Documents.

5.02 Labor, *Materials* and Equipment

A. Seller shall provide competent, qualified and trained personnel in all aspects of its performance of the Contract.

B. All equipment, products and material incorporated into the Goods shall be as specified, or if not specified, shall be new, of good quality and protected, assembled, used, connected, applied, cleaned and conditioned in accordance with the original manufacturer's instructions, except as otherwise may be provided in the Contract Documents.

5.03 Compliance with Laws and Regulations, Standards, Specifications and Codes

A. Seller shall comply with all Laws and Regulations applicable to the furnishing of the Goods and Special Services.

5.04 Or *Equals*

A. Whenever an item of material or equipment to be incorporated into the Goods is specified or described in the Contract Documents by using the name of a proprietary item or the name of a particular supplier or manufacturer, the specification or description is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or-equal" item is permitted, other items of material or equipment or material or equipment of other suppliers or manufacturers may be submitted to Buyer for Engineer's review.

1. If in Engineer's sole discretion, such an item of material or equipment proposed by Seller is functionally equal to that named and sufficiently similar so that no change in related work will be required, it may be considered by Engineer as an "or-equal" item.

2. For the purposes of this paragraph, a proposed item of material or equipment may be considered functionally equal to an item so named if:

a. in the exercise of reasonable judgment, Engineer determines that: 1) it is at least equal in quality, durability, appearance, strength, and design characteristics; and 2) it will reliably perform at least equally well the function imposed by the design concept of the completed Project as a functioning whole; and

b. Seller certifies that: 1) there is no increase in any cost including capital, installation or operating to Buyer; and 2) the proposed item will conform substantially, even with deviations, to the detailed requirements of the item named in the Contract Documents.

B. *Engineer's Evaluation:* Engineer will be allowed a reasonable time within which to evaluate each proposal or submittal made pursuant to Paragraph 5.04.A. Engineer will be the sole judge of acceptability. No "or-equal" will be ordered, manufactured or utilized until Engineer's review is complete, which will be evidenced by an approved Shop Drawing. Engineer will advise Buyer and Seller in writing of any negative determination. Notwithstanding Engineer's approval of an "or-equal" item, Seller shall remain obligated to comply with the requirements of the Contract Documents.

C. *Special Guarantee:* Buyer may require Seller to furnish at Seller's expense a special performance guarantee or other surety with respect to any such proposed "or-equal."

D. *Data:* Seller shall provide all data in support of any such proposed "or-equal" at Seller's expense.

5.05 *Taxes*

A. Seller shall be responsible for all taxes and duties arising out of the sale of the Goods and the furnishing of Special Services. All taxes are included in the Contract Price.

5.06 Shop Drawings and Samples

A. Seller shall submit Shop Drawings and Samples to Buyer for Engineer's review and approval in accordance with the schedule required in Paragraph 2.06.A. All submittals will be identified as required and furnished in the number of copies specified in the Contract Documents. The data shown on the Shop Drawings will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Seller proposes to provide.

B. Where a Shop Drawing or Sample is required by the Contract Documents, any related work performed prior to Engineer's approval of the pertinent submittal will be at the sole expense and responsibility of Seller.

C. *Submittal Procedures*

1. Before submitting each Shop Drawing or Sample, Seller shall have determined and verified:

a. all field measurements (if required), quantities, dimensions, specified performance criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto; and

b. that all materials are suitable with respect to intended use, fabrication, shipping, handling, storage, assembly, and installation pertaining to the furnishing of Goods and Special Services.

2. Seller shall also have reviewed and coordinated each Shop Drawing or Sample with the Contract Documents.

3. Each submittal shall include a written certification from Seller that Seller has reviewed the subject submittal and confirmed that it is in compliance with the requirements of the Contract Documents. Both Buyer and Engineer shall be entitled to rely on such certification from Seller.

4. With each submittal, Seller shall give Buyer and Engineer specific written notice of any variations that the Shop Drawing or Sample may have from the requirements of the Contract Documents. This notice shall be both in a written communication separate from the submittal and by specific notation on each Shop Drawing or Sample.

D. Engineer's Review

1. Engineer will provide timely review of Shop Drawings and Samples.

2. Engineer's approval of Shop Drawings or Samples will be subject to the standard of Paragraph 1.02.A.1. Engineer's approval will not relieve Seller from responsibility for any variation from the requirements of the Contract Documents unless Seller has in writing called Engineer's attention to each such variation at the time of each submittal as required by Paragraph 5.06.C.1. and Engineer has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample approval.

E. Resubmittal Procedures

1. Seller shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit as required new Samples for review and approval. Seller shall direct specific attention in writing to any revisions other than the corrections called for by Engineer on previous submittals.

5.07 Continuing Performance

A. Seller shall adhere to the progress schedule established in accordance with Paragraph 2.06.A., and the Goods shall be delivered and the Special Services furnished within the Contract Times specified in the Agreement.

B. Seller shall carry on the work and adhere to the progress schedule during all disputes or disagreements with Buyer. No work shall be delayed or postponed pending resolution of any disputes or disagreements.

5.08 Seller's Warranties and Guarantees

A. Seller warrants and guarantees to Buyer that the title to the Goods conveyed shall be proper, its transfer rightful, and free from any security interest, lien, or other encumbrance.

B. Seller warrants and guarantees to Buyer that all Goods and Special Services will conform with the Contract Documents, including any Samples approved by Engineer, and the Goods will be of merchantable quality. Engineer shall be entitled to rely on representation of Seller's warranty and guarantee.

C. Seller's warranty and guarantee hereunder excludes defects or damage caused by:

1. abuse, improper modification or improper maintenance or operation by persons other than Seller, or

2. normal wear and tear under normal usage.

D. Seller's obligation to furnish the Goods and Special Services in accordance with the Contract Documents shall be absolute. None of the following will constitute an acceptance of Goods or Special Services that are non-conforming, or a release of Seller's obligation to furnish the Goods and Special Services in accordance with the Contract Documents:

1. observations by Buyer or Engineer;

2. recommendation by Engineer or payment by Buyer of any progress or final payment;

3. use of the Goods by Buyer;

4. any acceptance by Buyer (subject to the provisions of Paragraph 8.02.D.1) or any failure to do so;

5. the issuance of a notice of acceptance by Buyer pursuant to the provisions of Article 8;

6. any inspection, test or approval by others; or

7. any correction of non-conforming Goods or Special Services by Buyer.

E. Buyer shall within a reasonable time notify Seller of any breach of Seller's warranties or guarantees. If Buyer receives notice of a suit or claim as a result of such breach, Buyer also may give Seller notice in writing to defend such suit or claim. If Seller fails to defend such suit or claim, Seller will be bound in any subsequent suit or claim against Seller by Buyer by any factual determination in the prior suit.

5.09 Indemnification

A. To the fullest extent permitted by Laws and Regulations, Seller shall indemnify and hold harmless Buyer, Engineer, and their officers, directors, shareholders, partners, employees, agents, consultants, contractors and subcontractors from any and all claims, costs, losses, and demands or judgments for damages for claims (including but not limited to fees and charges of engineers, architects, attorneys and other professionals and all court or arbitration or other dispute resolution costs) caused by, arising out of or relating to a negligent act or omission or the breach of any obligation under this Contract by Seller, or its officers, directors, shareholders, partners, employees, agents, consultants, contractors or subcontractors, or anyone for whom Seller is responsible, provided that any such claim, cost, loss, or damage;

1. is attributable to bodily injury, sickness, disease, or death, or to injury to or destruction of tangible property (other than the Goods or Special Services themselves), including the loss of use resulting therefrom; and

2. is caused in whole or in part by any negligent act or omission of Seller or any individual or entity directly or indirectly employed to furnish any of the Goods or Special Services or anyone for whose acts Seller may be liable, regardless of whether or not caused in part by any negligence or omission of an individual or entity indemnified hereunder or whether liability is imposed upon such indemnified party by Laws and Regulations regardless of the negligence of any such individual or entity.

B. The indemnification obligations of Seller under paragraph 5.09.A shall not extend to the liability of Engineer and Engineer's consultants or to the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them arising out of:

1. the preparation or approval of, or the failure to prepare or approve, maps, Drawings, opinions, reports, surveys, Change Orders, designs, or Specifications; or

2. giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

ARTICLE 6 - SHIPPING AND DELIVERY

6.01 Shipping

A. Seller shall select the carrier and bear all costs of packaging, transportation, insurance, special handling and any other costs associated with shipment and delivery.

6.02 Delivery

A. Seller shall deliver the Goods F.O.B. the Point of Destination in accordance with the Contract Times set forth in the Agreement, or other date agreed to by Buyer and Seller.

B. Seller shall provide written notice to Buyer at least 15 days before shipment of the manner of shipment and the anticipated delivery date. The notice shall also include any instructions concerning special equipment or services required at the Point of Destination to unload and care for the Goods. Seller shall also require the carrier to give Buyer at least 1 week of written notice and at least 24 hours notice by telephone prior to the anticipated hour of delivery.

C. Buyer will be responsible and bear all costs for unloading the Goods from carrier.

D. Buyer will assure that adequate facilities are available to receive delivery of the Goods during the Contract Times set forth in the Agreement, or another date agreed by Buyer and Seller.

E. No partial deliveries shall be allowed, unless permitted or required by the Contract Documents or agreed to in writing by Buyer.

6.03 Risk of Loss

A. Risk of loss and insurable interests transfer from Seller to Buyer upon Buyer's receipt of the Goods.

B. Notwithstanding the provisions of Paragraph 6.03.A, if Buyer rejects the Goods as non-conforming, the risk of loss on such Goods shall remain with Seller until Seller corrects the non-conformity or Buyer accepts the Goods.

ARTICLE 7 - CHANGES: SCHEDULE AND DELAY

7.01 Changes in the Goods and Special Services

A. Buyer may at any time, without notice to any surety, make changes in the Contract Documents within the general scope of the Contract.

B. If any such change or action by Buyer affects the Contract Price or Contract Times, Seller shall notify Buyer within 15 days after the occurrence of the event giving rise thereto, and written supporting data will be submitted to Buyer within 45 days after such occurrence. If Seller fails to do so, Seller waives any Claim for such adjustment.

C. Seller shall not suspend performance while Buyer and Seller are in the process of making such changes and any related adjustments.

7.02 Changes in Laws and Regulations

A. Changes in Laws or Regulations not known at the time of opening of Bids (or, on the Effective Date of the Agreement if there were no Bids) having an effect on the cost or time of furnishing the Goods and Special Services shall be the subject of an adjustment in Contract Price or Contract Times. If Buyer and Seller are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment, a Claim may be made therefor as provided in Paragraph 9.06.A.

7.03 Changing *Contract* Price or Contract Times

A. The Contract Price or Contract Times may only be changed by:

1. a Change Order;

2. a Written Amendment; or

3. a written unilateral order of Buyer, in which case Seller shall be entitled to an equitable adjustment in Contract Price or Contract Times for any reasonable and necessary costs or delays incurred by Seller to accommodate such a change.

B. If Seller is prevented from delivering the Goods or performing the Special Services within the Contract Times for any unforeseen reason beyond its control and not attributable to its actions or inactions, then Seller shall be entitled to an adjustment of the Contract Times to the extent attributable to such reason. Such reasons include fire, floods, epidemics, abnormal weather conditions, acts of God, acts of war, directions by government authority, and other like matters. If such an event occurs and delays Seller's performance, Seller shall notify Buyer in writing within 15 days of the beginning of the event causing the delay, stating the reason therefor.

C. Contract Times will not be modified for delays within the control of Seller, including labor strife, transportation shortages or delays at Seller's facilities. Delays attributable to and within the control of Seller's subcontractors or suppliers shall be deemed to be delays within the control of Seller.

D. If Seller is prevented from delivering the Goods or furnishing the Special Services within the Contract Times due to the actions or inactions of Buyer, Seller shall be entitled to any reasonable and necessary additional costs arising out of such delay to the extent directly attributable to Buyer.

E. Neither Buyer nor Seller shall be entitled to any damages arising from delays which are beyond the control of both Buyer and Seller, including but not limited to fires, floods, epidemics, abnormal weather conditions, acts of God, acts of war, direction by government authority, and other like matters.

ARTICLE 8 - BUYER'S RIGHTS

8.01 Inspections and Testing

A. General

1. Buyer shall have the right to perform, or cause to be performed, reasonable inspections and require reasonable tests of the Goods at Seller's facility, and at the Point of Destination. Seller shall allow Buyer a reasonable time to perform such inspections or tests.

2. Seller shall bear all expenses, except for travel, lodging and subsistence expenses of Buyer's representatives, for inspections and tests at Seller's facility, but Buyer shall be entitled to reimbursement from Seller of travel, lodging and subsistence expenses of Buyer's representatives if the Goods are non-conforming.

3. Buyer shall bear all expenses, except for travel, lodging and subsistence expenses of Seller's representatives, for inspections and tests at the Point of Destination, but Buyer shall be entitled to reimbursement from Seller for Buyer's expenses for reinspection or retesting if, on the basis of an initial inspection or testing, the Goods are determined to be non-conforming.

4. Seller shall provide Buyer 30 days written notice of the readiness of the Goods for all inspections, tests, or approvals which the Contract Documents specify are to be observed by Buyer prior to shipment.

5. Buyer will give Seller timely notice of all specified tests, inspections and approvals of the Goods which are to be conducted at the Point of Destination.

6. If, on the basis of any inspections or testing, the Goods appear to be conforming, Buyer will give Seller prompt notice thereof. If on the basis of said inspections or testing, the Goods appear to be non-conforming, Buyer will give Seller prompt notice thereof and will advise Seller of the remedy Buyer elects under the provisions of Paragraph 8.02.

7. Neither payments made by Buyer to Seller prior to any tests or inspections, nor any tests or inspections shall constitute acceptance of non-conforming Goods, or prejudice Buyer's rights under the Contract.

B. Inspection on Delivery

1. Buyer or Engineer will inspect the Goods upon delivery solely for purposes of identifying the Goods and general verification of quantities and observation of apparent condition in order to provide a basis for a progress payment. Such inspection will not be construed as final or as receipt of any Goods and Special Services that, as a result of subsequent inspections and tests, are determined to be non-conforming.

2. Within ten days of such inspection, Buyer shall provide Seller with written notice of Buyer's determination regarding conformity of the Goods. In the event Buyer does not provide such notice, it will be presumed that the Goods appear to be conforming.

3. If, on the basis of the inspection specified in Paragraph 8.01.B.1, the Goods appear to be conforming, Buyer's notice thereof to Seller will acknowledge receipt of the Goods.

C. Final Inspection

1. After all of the Goods have been incorporated into the Project, tested in accordance with such testing requirements as are specified, and are functioning as intended, Buyer or Engineer will make a final inspection.

2. If, on the basis of the final inspection, the Goods are conforming, Buyer's notice thereof will constitute Buyer's acceptance of the Goods.

3. If, on the basis of the final inspection, the Goods are non-conforming, Buyer will identify the non-conformity in writing.

8.02 Non-Conforming Goods or Special Services

A. If, on the basis of inspections and testing prior to delivery, the Goods appear to be non-conforming, or if at any time after Buyer has acknowledged receipt of delivery and before the expiration of the correction period described in Paragraph 8.03, Buyer determines that the Goods are non-conforming, Seller shall promptly, without cost to Buyer and in response to written instructions from Buyer, either correct such non-conforming Goods, or, if rejected by Buyer, remove and replace the non-conforming Goods with conforming Goods, including all work required for reinstallation.

B. Buyer's Rejection of Non-Conforming Goods

1. If Buyer elects to reject the Goods in whole or in part, Buyer's notice to Seller will describe in sufficient detail the non-conforming aspect of the Goods. If Goods have been delivered to Buyer, Seller shall promptly, and within the Contract Times, remove and replace the rejected Goods.

2. Seller shall bear all costs, losses and damages attributable to the removal and replacement of the non-conforming Goods as provided in Paragraph 8.02.E.

3. Upon rejection of the Goods, Buyer retains a security interest in the Goods or to the extent of any payments made and expenses incurred in their testing and inspection.

C. Remedying Non-Conforming Goods or Special Services

1. If Buyer elects to permit the Seller to modify the Goods to remove the non-conformance, Seller shall promptly provide a schedule for such modifications and shall make the Goods conforming within a reasonable time.

2. If Buyer notifies Seller in writing that any of the Special Services are non-conforming, Seller shall promptly provide conforming services acceptable to Buyer. If Seller fails to do so, Buyer may delete the Special Services and reduce the Contract Price a commensurate amount.

D. Buyer's Acceptance of Non-Conforming Goods

1. Instead of requiring correction or removal and replacement of non-conforming Goods discovered either before or after final payment, Buyer may accept the non-conforming Goods. Seller shall bear all costs, losses, and damages attributable to Buyer's evaluation of and determination to accept such non-conforming Goods as provided in Paragraph 8.02.E.

E. Seller shall pay all claims, costs, losses, and damages, including but not limited to all fees and charges for re-inspection, retesting and for any engineers, architects, attorneys and other professionals, and all court or arbitration or other dispute resolution costs arising out of or relating to the non-conforming Goods or Special Services, including the correction or removal and replacement of the non-conforming Goods and the replacement of property of Buyer and others destroyed by the correction or removal and replacement of the non-conforming Goods, or the obtaining of conforming Special Services from others.

8.03 Correction Period

A. Seller's responsibility for correcting all non-conformities in the Goods will extend for a period of one year after the earlier of the date on which Buyer has placed the Goods in continuous service or the date of final payment, or for such longer period of time as may be prescribed by Laws or Regulations or by the terms of any specific provisions of the Contract Documents.

ARTICLE 9 - ROLE OF ENGINEER

9.01 Duties and Responsibilities

The duties and responsibilities and the limitations of authority of Engineer are set forth in the Contract Documents.
Note that the Buyer's Decision in the project will be the final.

9.02 Clarifications and Interpretations

A. Engineer will issue with reasonable promptness such written clarifications or interpretations of the Contract Documents as Engineer may determine necessary, which shall be consistent with or reasonably inferable from the overall intent of the Contract Documents. Such written clarifications and interpretations will be binding on Buyer and Seller. If either Buyer or Seller believes that a written clarification or interpretation justifies an adjustment in the Contract Price or Contract Times, either may make a Claim therefor.

9.03 Authorized Variations

A. Engineer may authorize minor deviations or variations in the Contract Documents by: 1) issuance of approved Shop Drawings when such change or deviation was duly noted by Seller as required in Paragraph 5.06.C.4, or 2) a Field Order.

9.04 Rejecting Non-Conforming Goods and Special Services

A. Engineer will have the authority to disapprove or reject Goods or Special Services which Engineer believes to be non-conforming.

9.05 Decisions on Requirements of Contract Documents

A. Engineer will be the initial interpreter of the Contract Documents and judge of the acceptability of the Goods and Special Services. Claims, disputes and other matters relating to the acceptability of the Goods and Special Services or the interpretation of the requirements of the Contract Documents pertaining to Seller's performance will be referred initially to Engineer in writing with a request for a formal decision in accordance with this paragraph.

B. When functioning as interpreter and judge under this Paragraph 9.05, Engineer will not show partiality to Buyer or Seller and will not be liable in connection with any interpretation or decision rendered in good faith in such capacity. The rendering of a decision by Engineer pursuant to this Paragraph 9.05 with respect to any such Claim, dispute, or other matter (except any which have been waived by the making or acceptance of final payment as provided in Paragraph 10.07) will be a condition precedent to any exercise by Buyer or Seller of such rights or remedies as either may otherwise have under the Contract Documents or by Laws or Regulations in respect of any such Claim, dispute, or other matter.

9.06 Claims and Disputes

A. *Notice*: Written notice of each Claim, dispute or other matter relating to the acceptability of the Goods and Special Services or the interpretation of the requirements of the Contract Documents pertaining to Seller's performance shall be delivered by the claimant to Engineer and the other party to the Agreement within 15 days after the occurrence of the event giving rise thereto, and written supporting data will be submitted to Engineer and the other party within 45 days after such occurrence unless Engineer allows an additional period of time to ascertain more accurate data.

B. *Engineer's Decision*: Engineer will render a decision in writing within 30 days after receipt of the last submittal of the claimant or the last submittal of the opposing party, if any. Engineer's written decision on such Claim, or dispute, or other matter will be final and binding upon Buyer and Seller unless:

1. an appeal from Engineer's decision is made within the time limits and in accordance with the dispute resolution procedures set forth in Article 13; or

2. if no such dispute resolution procedures have been set forth, a written notice of intention to appeal is delivered by Buyer or Seller to the other and to Engineer within 30 days after the date of such decision, and a formal proceeding is instituted by the appealing party in a forum of competent jurisdiction within 60 days after the date of such decision (unless otherwise agreed to in writing by Buyer and Seller), to exercise such rights or remedies as the appealing party may have with respect to such Claim, dispute, or other matter in accordance with applicable Laws and Regulations.

C. If Engineer does not render a formal decision in writing within the time stated in Paragraph 9.06.B., a decision denying the Claim in its entirety shall be deemed to have been issued 31 days after receipt of the last submittal of the claimant or the last submittal of the opposing party, if any.

ARTICLE 10 - PAYMENT

10.01 Applications for Progress Payments

A. Seller shall submit to Buyer for Engineer's review Applications for Payment filled out and signed by Seller and accompanied by such supporting documentation as is required by the Contract Documents and also as Buyer or Engineer may reasonably require. The timing and amounts of progress payments shall be as stipulated in the Agreement.

1. The second Application for Payment, and all subsequent Applications for Payment, will be submitted after receipt of the Goods has been acknowledged in accordance with Paragraph 8.01.B and will be accompanied by a bill of sale, invoice or other documentation satisfactory to Buyer warranting that Buyer has rightfully received good title to the Goods from Seller and that the Goods are free and clear of all liens. Such documentation will include releases and waivers from all parties with viable lien rights. In the case of

multiple deliveries of Goods, additional Applications for Payment accompanied by the required documentation will be submitted as Buyer acknowledges receipt of additional items of the Goods.

10.02 Review of Applications for Progress Payments

A. Engineer will, within ten days after receipt of each Application for Payment, either indicate in writing a recommendation of payment and present the Application to Buyer, or return the Application to Seller indicating in writing Engineer's reasons for refusing to recommend payment. In the latter case, Seller may make the necessary corrections and resubmit the Application.

1. Engineer’s recommendation of payment requested in the first Application for Payment will constitute a representation by Engineer, based on Engineer’s review of the Application for Payment and the accompanying data, that the Shop Drawings and Samples have been reviewed and approved as required by the Contract Documents and Seller is entitled to payment of the amount recommended.

2. Engineer’s recommendation of payment requested in the Application for Payment submitted upon Buyer’s acknowledgment of receipt of the Goods will constitute a representation by Engineer, based on Engineer’s review of the Application for Payment and the accompanying data Seller is entitled to payment of the amount recommended. Such recommendation will not constitute a representation that Engineer has made a final inspection of the Goods, that the Goods are free from non-conformities, acceptable or in conformance with the Contract Documents, that Engineer has made any investigation as to Buyer’s title to the Goods, that exhaustive or continuous inspections have been made to check the quality or the quantity of the Goods beyond the responsibilities specifically assigned to Engineer in the Contract Documents or that there may not be other matters or issues between the parties that might entitle Seller to additional payments by Buyer or Buyer to withhold payment to Seller.

3. Engineer may refuse to recommend that all or any part of a progress payment be made, or Engineer may nullify all or any part of any payment previously recommended if, in Engineer's opinion, such recommendation would be incorrect or if on the basis of subsequently discovered evidence or subsequent inspections or tests Engineer considers such refusal or nullification necessary to protect Buyer from loss because the Contract Price has been reduced, Goods are found to be non-conforming, or Seller has failed to furnish acceptable Special Services.

10.03 Amount and Timing of Progress Payments

A. Subject to Paragraph 10.02.A., the amounts of the progress payments will be as provided in the Agreement. Buyer shall within 30 days after receipt of each Application for Payment with Engineer's recommendation pay Seller the amount recommended; but, in the case of the Application for Payment upon Buyer's acknowledgment of receipt of the Goods, said 30-day period may be extended for so long as is necessary (but in no event more than 60 days) for Buyer to examine the bill of sale and other documentation submitted therewith. Buyer shall notify Seller promptly of any deficiency in the documentation and shall not unreasonably withhold payment.

10.04 Suspension of or Reduction in Payment

A. Buyer may suspend or reduce the amount of progress payments, even though recommended for payment by Engineer, under the following circumstances:

1. Buyer has reasonable grounds to conclude that Seller will not furnish the Goods or the Special Services in accordance with the Contract Documents,

2. Buyer has requested in writing assurances from Seller that the Goods or Special Services will be delivered or furnished in accordance with the Contract Documents, and Seller has failed to provide adequate assurances within ten days of Buyer’s written request.

B. If Buyer refuses to make payment of the full amount recommended by Engineer, Buyer will provide Seller and Engineer immediate written notice stating the reason for such action and promptly pay Seller any amount remaining after deduction of the amount withheld. Buyer shall promptly pay Seller the amount withheld when Seller corrects the reason for such action to Buyer’s satisfaction.

10.05 Final Application for Payment

A. After Seller has corrected all non-conformities to the satisfaction of Buyer and Engineer, furnished all Special Services, and delivered all documents required by the Contract Documents, Engineer will issue to Buyer and Seller a notice of acceptability. Seller may then make application for final payment following the procedure for progress payments. The final Application for Payment will be accompanied by all documentation called for in the Contract Documents, a list of all unsettled claims and such other data and information as Buyer or Engineer may reasonably require.

10.06 Final Payment

A. If, on the basis of the review of the final Application for Payment and accompanying documentation, Engineer is satisfied that the Goods and Special Services have been furnished in accordance with the Contract Documents, and that Seller's other obligations under the Contract Documents have been fulfilled, Engineer will, within ten days after receipt of the final Application for Payment, recommend in writing final payment subject to the provisions of Paragraph 10.07 and present the Application to Buyer. Otherwise, Engineer will return the Application to Seller, indicating the reasons for refusing to recommend final payment, in which case Seller shall make the necessary corrections and resubmit the Application. If the Application and accompanying documentation are appropriate as to form and substance, Buyer shall, within 30 days after receipt thereof, pay Seller the amount recommended by Engineer.

10.07 Waiver of Claims

A. The making and acceptance of final payment will constitute:

1. a waiver of all Claims by Buyer against Seller, except Claims arising from unsettled liens and Claims, from non-conformities in the Goods or Special Services appearing after final payment, from failure to comply with the Contract Documents or the terms of any special guarantees specified therein, or from Seller's continuing obligations under the Contract Documents; and

2. a waiver of all Claims by Seller against Buyer other than those previously made in accordance with the requirements herein and expressly noted in writing by Seller as still unsettled in its final Application for Payment.

ARTICLE 11 - CANCELLATION, SUSPENSION, AND TERMINATION

11.01 Cancellation

A. Buyer has the right to cancel the Contract, without cause, at any time prior to delivery of the Goods by written notice. Cancellation pursuant to the terms of this paragraph shall not constitute a breach of contract by Buyer. Upon cancellation:

1. Buyer shall pay Seller for Goods, specially manufactured for the Project, plus any documented reasonable direct and indirect costs incurred by Seller in producing such Goods not recovered by payment for the reasonable value of the Goods.

2. For Goods which are not specially manufactured for the Project, Seller shall be entitled to a restocking charge of 10 percent of the unpaid Contract Price of such Goods. Buyer and Engineer shall be notified of such goods, if any, prior to the procurement. Procurement of such good is subject to approval from the Engineer.

11.02 Suspension of Performance by Buyer

A. Buyer has the right to suspend performance of the Contract, without cause, by written notice. Upon suspension under this paragraph, Seller shall be entitled to an increase in the Contract Times and Contract Price caused by the suspension, provided that performance would not have been suspended or delayed for causes attributable to Seller.

11.03 Suspension of Performance by Seller

A. Subject to the provisions of Paragraph 5.07.B, Seller may suspend the furnishing of the Goods and Special Services only under the following circumstance:

1. Seller has reasonable grounds to conclude that Buyer will not perform its future payment obligations under the Contract. (“Reasonable grounds” shall not include a pending dispute or disagreement with Buyer) and,

2. Seller has requested in writing assurances from Buyer that future payments will be made in accordance with the Contract, and Buyer has failed to provide such assurances within ten days of Seller’s written request.

11.04 Breach and Termination

A. Buyer’s Breach

1. Buyer shall be deemed in breach of the Contract if it fails to comply with any material provision of the Contract Documents, including but not limited to:

a. wrongful rejection or revocation of Buyer’s acceptance of the Goods,

b. failure to make payments in accordance with the Contract Documents, or

c. wrongful repudiation of the Contract.

2. Seller shall have the right to terminate the Contract for cause by declaring a breach should Buyer fail to comply with any material provisions of the Contract. Upon termination, Seller shall be entitled to all remedies provided by Laws and Regulations.

a. In the event Seller believes Buyer is in breach of its obligations under the Contract, Seller shall provide Buyer with reasonably prompt written notice setting forth in sufficient detail the reasons for declaring that it believes a breach has occurred. Buyer shall have seven days from receipt of the written notice declaring the breach (or such longer period of time as Seller may grant in writing) within which to cure the alleged breach.

B. Seller’s Breach

1. Seller shall be deemed in breach of the Contract if it fails to comply with any material provision of the Contract Documents, including, but not limited to:

a. failure to deliver the Goods or perform the Special Services in accordance with the Contract Documents,

b. wrongful repudiation of the Contract, or

c. delivery or furnishing of non-conforming Goods or Special Services.

2. Buyer may terminate Seller's right to perform the Contract for cause by declaring a breach should Seller fail to comply with any material provision of the Contract Documents. Upon termination, Buyer shall be entitled to all remedies provided by Laws and Regulations.

a. In the event Buyer believes Seller is in breach of its obligations under the Contract, and except as provided in Paragraph 11.04.B.2.b, Buyer shall provide Seller with reasonably prompt written notice setting forth in sufficient detail the reasons for declaring that it believes a breach has occurred. Seller shall have seven days from receipt of the written notice declaring the breach (or such longer period of time as Buyer may grant in writing) within which to cure the alleged breach.

b. If and to the extent that Seller has provided a performance bond under the provisions of Paragraph 4.01, the notice and cure procedures of that bond, if any, shall supersede the notice and cure procedures of Paragraph 11.04.B.2.a.

ARTICLE 12 - LICENSES AND FEES

12.01 Intellectual Property and License Fees

A. Unless specifically stated elsewhere in the Contract Documents, Seller is not transferring any intellectual property rights, patent rights, or licenses for the Goods delivered. However, in the event the Seller is manufacturing to Buyer's design, Buyer retains all intellectual property rights in such design.

B. Seller shall pay all license fees and royalties and assume all costs incident to the use or the furnishing of the Goods, unless specified otherwise by the Contract Documents.

12.02 Seller's Infringement

A. Subject to Paragraph 12.01.A, Seller shall indemnify and hold harmless Buyer, Engineer and their officers, directors, partners, employees, agents, consultants, contractors, and subcontractors from and against all claims, costs, losses, damages, and judgments (including but not limited to all fees and charges of engineers, architects, attorneys and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement or alleged infringement of any United States or foreign patent or copyright by any of the Goods delivered hereunder.

B. In the event of suit or threat of suit for intellectual property infringement, Buyer will notify Seller within a reasonable time of receiving notice thereof.

C. Upon written demand from Buyer, Seller shall be given the opportunity to defend the claim or suit, including negotiating a settlement. Seller shall have control over such claim or suit, provided that Seller agrees to bear all expenses and to satisfy any adverse judgment thereof.

1. If Seller fails to defend such suit or claim after written demand by Buyer, Seller will be bound in any subsequent suit or claim against Seller by Buyer by any factual determination in the prior suit or claim.

2. If Buyer fails to provide Seller the opportunity to defend such suit or claim after written demand by Seller, Buyer shall be barred from any remedy against Seller for such suit or claim.

D. If a determination is made that Seller has infringed upon intellectual property rights of another, Seller may obtain the necessary licenses for Buyer's benefit, or replace the Goods and provide related design and construction as necessary to avoid the infringement at Seller's own expense.

12.03 Buyer's Infringement

A. Buyer shall indemnify and hold harmless Seller, and its officers, directors, partners, employees, agents, consultants, contractors, and subcontractors from and against all claims, costs, losses, damages, and judgments (including but not limited to all fees and charges of engineers, architects, attorneys and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement or alleged infringement of any United States or foreign patent or copyright caused by Seller's compliance with Buyer's design of the Goods or Buyer's use of the Goods in combination with other materials or equipment in any process (unless intent of such use was known to Seller and Seller had reason to know such infringement would result).

B. In the event of suit or threat of suit for intellectual property infringement, Seller must within a reasonable time after receiving notice thereof notify Buyer.

C. Upon written demand from Seller, Buyer shall be given the opportunity to defend the claim or suit, including negotiating a settlement. Buyer shall have control over such claim or suit, provided that Buyer agrees to bear all expenses and to satisfy any adverse judgment thereof.

1. If Buyer fails to defend such suit or claim after written demand by Seller, Buyer will be bound in any

subsequent suit or claim against Buyer by Seller by any factual determination in the prior suit or claim.

2. If Seller fails to provide Buyer the opportunity to defend such suit or claim after written demand by Buyer, Seller shall be barred from any remedy against Buyer for such suit or claim.

12.04 Reuse of Documents

A. Neither Seller nor any other person furnishing any of the Goods or Special Services under a direct or indirect contract with Seller shall: (1) acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of Engineer or its consultants, including electronic media versions; or (2) reuse any of such Drawings, Specifications, other documents, or copies thereof on any other project without written consent of Buyer and Engineer and specific written verification or adaptation by Engineer. This prohibition will survive termination or completion of the Contract. Nothing herein shall preclude Seller from retaining copies of the Contract Documents for record purposes.

ARTICLE 13 - DISPUTE RESOLUTION

13.01 Dispute Resolution Method

A. Disputes between Buyer and Seller will be resolved as set forth in the Supplementary Conditions. If no method and procedure has been set forth, and subject to the provisions of Paragraphs 9.05 and 9.06, Buyer and Seller may exercise such rights or remedies as they have under Controlling Law.

ARTICLE 14 - MISCELLANEOUS

14.01 Giving Notice

A. Whenever any provision of the Contract Documents requires the giving of written notice, it will be deemed to have been validly given if delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or if delivered at or sent by registered or certified mail, postage prepaid, to the last business address known to the giver of the notice.

14.02 Controlling Law

A. This Contract is to be governed by the law of the state in which the Point of Destination is located.

14.03 Computation of Time

A. When any period of time is referred to in the Contract Documents by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day shall be omitted from the computation.

14.04 Cumulative *Remedies*

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract Documents, and the provisions of this paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right, and remedy to which they apply.

14.05 Survival of Obligations

A. All representations, indemnifications, warranties and guarantees made in, required by, or given in accordance with the Contract Documents, as well as all continuing obligations indicated in the Contract Documents, will survive final payment, completion and acceptance of the Goods or Special Services and termination or completion of the Agreement.

ARTICLE 15 - INSURANCE REQUIREMENTS

The seller shall carry following insurance throughout the active contract duration

A. General Liability insurance with a limit of $5M, including additional insured coverage for KRCD for ongoing and completed operations.

B. Professional liability insurance with a limit of $5M, coverage to be in place for the duration of the project and for 3 years after the completion of the project.

C. Commercial Auto Liability insurance with a $1M limit insurance ‘any auto’. If supplier does not own any vehicles then coverage for “Hired and non-owned” auto in the amount of $1M.

D. Workers Compensation insurance for statutory limits required by law including employer’s liability coverage in the amount of $1M combined single limit.

Pine Flat Unit-4 Project

Water to Wire Equipment Procurement Package-Contract Documents

SUPPLEMENTARY CONDITIONS

For General Conditions (GC) Art. 3, 3.02, *Laws and Regulations, Standards, Specifications and Codes*, add the following:
This contract will be interpreted and enforced according to the laws of the State of California. Should litigation arise related to the enforcement or interpretation of the agreement in any way, Equipment Supplier and Owner agree that such litigation shall be brought and venue will lie in Fresno County, California.

For GC Art. 5, Seller's Responsibilities, add the following:
In addition to the requirements of the GC for timely Shop Drawing submittals, additional provisions regarding changes or revisions made by the Equipment Supplier which will require redesign of the powerhouse or any ancillary facilities, will be as set forth in the following paragraphs:

1. For changes or revisions made by Equipment Supplier after initial 30-day Preliminary Design Drawings submittal of confirmed equipment dimensions and locations, and for each subsequent scheduled submittal that changes dimensions and locations before Award of the Construction Contract, Engineer will record time and costs required by Owner and Engineer and their consultants in evaluating the changes, and in making changes in the Construction Documents occasioned thereby.
2. For changes or revisions made by Equipment Supplier during the course of the project construction, Engineer will record time and costs required by Owner and Engineer and their consultants in evaluating the changes, in making changes in the Construction Documents, as required, and in computing changes in construction costs occasioned thereby.
3. Equipment Supplier shall reimburse Owner for all costs for services of Owner, Engineer and their consultants for making changes in the Construction Documents, as related in 1 and 2, above, for evaluating the changes in construction costs, and for all added construction costs occasioned by redesign during construction phase.
4. Revised shipping information: all revisions to shipping information provided within the bids shall be submitted within the specified 120-day submittal period. This revised information will be given to the construction contract bidders for basing their handling and storage costs. All additional costs resulting from subsequent changes to shipping information different from that

submitted by Equipment Supplier after the 120-day submittal period will be deducted from payments due the Equipment Supplier.

For GC Art. 5.05, add the following:
The liquidated damages specified herein are cumulative and are limited to 15 percent of the Contract Price and shall be withheld from moneys due the Equipment Supplier.

For GC Art. 7.03 Changing Contract Price or Contract Terms, add the following:
Unit Price Contract Items: For Contract Items bid on a unit price basis, the estimated quantities in the Bid Form are approximate and are given only as a basis for comparison of bids. Owner does not expressly, or by implication, warrant that the actual amount of work will correspond to the estimated quantities. Owner reserves the right to increase or decrease the amount of work performed under unit price contract items, or to omit such work altogether. No adjustments to the Contract unit prices will be made, nor will any claim for loss of anticipated profit be allowed, on account of any such increase, decrease or omission. Payment for unit price contract items will be made at the Contract unit prices stated in the Equipment Supplier's Proposal, for the quantities of work directed by the Engineer to be performed and actually performed.

For GC Art. 10 Payment, add the following:
In addition to the Goods specified for delivery, all specified supplementary data and documents shall have been delivered to and accepted by the Engineer.

Add new Article 15, Full Operation Date
15.1 Definition of Full Operation Date: The first date, after all essential operational elements of the power Plant have been completed, and after the startup tests have been completed, on which all features and equipment are capable of operating simultaneously in such condition and adjustment that the plant is capable of continuous delivery into the transmission lines at full capacity for the available head and flow conditions.

15.2 The fact that the Power Plant has met the standards of Art. 15.1 above must be confirmed by satisfactory completion of performance tests, which will be conducted as soon as possible and will commence not later than 30 days after the completion of testing described herein. For the purpose of this paragraph, one of the performance tests, which shall follow the startup tests, shall include the satisfactory operation of the plant for a period of 30 consecutive days.

15.3 The 30-day performance test requirement of paragraph 15.2 above shall be continuous, except for any scheduled shutdown for maintenance, adjustment and correction; or for limited uncontrolled shutdowns, which will be determined by the Engineer on a case-by-case basis.

15.3.1 Uncontrolled shutdowns may or may not result in the start of a new 30-day period. For all shutdowns, a timely explanation to Engineer is required to confirm the understanding relative to the effect of the shutdown on the 30-day performance test.

15.3.2 Periods of unsatisfactory performance shall not count toward the 30-day performance test requirement.

15.3.3 Unsatisfactory performance, not included shutdowns identified above, shall be considered as any uncorrected condition which affects the ability of the hydro generator to operate as specified herein, or which significantly increases the operation or maintenance cost.

15.4 The Scheduled Full Operation Date shall be determined at the Project Kick-off meeting.

15.5 The Actual Full Operation Date will be the date confirmed by performance testing as specified in paragraph 15.2, above. Final payment under this contract will not be made before the Actual Full Operation Date and completion of performance testing. The supplier shall have submitted all the required project documentation and that the Engineer shall have final approved all of them prior to the final payment.

15.6 The responsibility of the Equipment Supplier with respect to the Scheduled Full Operation Date is limited to the responsibility to deliver acceptable Goods meeting the requirements of the Procurement Documents within the specified times and to furnish the Special Services in a timely manner.

Add new Article 16, Penalty For Failure to Meet Guaranteed Output

16.1 The Contract Price for the turbine-generator shall be reduced by $5000 for each kilowatt by which the actual output is less than the guaranteed output, measured by field tests as specified herein.

Add new Article 17, Detailed and Erection Drawings

17.1 Before proceeding with fabrication or manufacture of Equipment Supplier designed and furnished materials and equipment, Equipment Supplier shall submit to the Engineer the designs, design computations when requested, detailed specifications, general assembly drawings of the equipment, and sufficient subassembly drawings, details, and control and wiring diagrams to demonstrate fully that all parts will conform to the provisions and intent of the Procurement Documents and to the requirements of their installation, operation, and maintenance. These submissions shall substantially conform to the Drawings and shall show all necessary dimensions; any and all field joints required; and subassemblies in which the Equipment Supplier proposes to ship the equipment; locations and sizes of auxiliary connections for oil, grease, water, and air; and the terminal boxes and wire sizes for electrical circuits. Equipment Supplier shall submit to the Engineer, before proceeding with fabrication or purchase, Shop Drawings, Product Data, and Samples as appropriate to items designed but not detailed on the Drawings.

SECTION 01010
SUMMARY OF WORK

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Summary of Work.

B. Access to the Site.

C. Intent.

D. Work by Others.

E. Procurement Documents.

1.2 SUMMARY OF WORK

A. Procurement of Goods, including the design, preparation of outline, arrangement and detailed Shop Drawings, manufacture, fabrication, shop assembly and testing of specified equipment and accessories:

1. Turbine, horizontal Francis type.
2. Generator, horizontal synchronous type, including rotating brushless excitation.
3. Generator Termination Cabinet.
4. Metal clad Generator Switchgear.
5. Turbine Shutoff Valve.
6. Turbine Shutoff Valve Controller.
7. High Pressure Digital Governor.
8. Combined HPU for Governor and TSV Servomotors
9. Turbine Generator Control Switchboard.
10. Generator Termination Cabinet.
11. ISO Metering Cabinet.

B. Delivery to Engineer a major components list for all Goods included in the Work of the Contract.

C. Delivery of Submittals including Drawings, Calculations, Equipment Supplier's Instructions for erection and installation, Project specific Operation and Maintenance Manuals and Record Drawings in accordance with the delivery schedule.

D. Special Services include providing one or more Equipment Supplier's Field Service Representatives to supervise installation, startup, commissioning, acceptance tests and initial operation of equipment furnished as Goods under this contract.

E. Delivery of Goods, including delivery to project site as specified in Article 5 of the Agreement.

F. Reference Drawings are provided for illustrative purposes only to generally show the existing structure, features, facilities, and limited details of the proposed new structure and equipment. Equipment Supplier may propose alternative locations for new equipment as required to best suit its designs, within existing constraints. The proposed alternative locations shall be submitted for Engineer review and receive approval before any changes are implemented.

1.3 ACCESS TO THE SITE

A. Pine Flat Dam is located on the Kings River in the Central Valley of Fresno County, approximately 31 miles ENE from the City of Fresno, California, off State Highway 180.

1.4 INTENT

A. These Specifications utilize the Construction Specifications Institute (CSI) 16 division format. Sections of Division 1, General Requirements, shall govern the execution of all Sections of the Specifications.

B. All Services, Equipment, and Work specified herein shall be provided under a single Equipment Supplier Procurement Contract. The Equipment Supplier may, subject to the review and approval of the Engineer, subcontract specific Services, Equipment, or Work as required. Any such subcontracted Services, Equipment, and Work must fully conform to and comply with the terms and conditions, responsibilities and obligations, and technical requirements of these Contract Documents. Equipment Supplier shall be responsible for all Services, Equipment, and Work described herein, whether self-performed or performed by Subcontractors.

C. Furnish, Supervise, and Commission.

1. Furnish means to design, detail, fabricate, procure, assemble, test, supply and deliver to project sites, ready for installation or use. All equipment under the scope shall also be tested for integration, as much as possible, at the supplier's factory.

2. Supervise means to provide all supervision services during all equipment or work necessary or desirable to place in position for service, complete and ready for intended use, including removal and disposal of features to be demolished and not reused.

3. Commission means to checkout, commission, and test, complete and ready for intended use.

1.5 WORK BY THE OTHERS

A. Work to be provided by others prior to, concurrent with, or after the work of this Contract, and which is excluded from this Contract:

1. Receiving, unloading and storing Goods at point of delivery.

2. Installing anchor bolts and other similar items.

3. Field installation of Equipment.

4. Field coating.

5. Furnishing external power and control wiring and conduit, except as otherwise specified.

6. Field assembly, fitting, shoring, rigging, and erection platforms.

7. Field testing, except as otherwise specified.

B. Design and construction of concrete foundations and powerhouse structure, powerhouse auxiliary systems and interconnections, will be based on Engineer-approved equipment Shop Drawings furnished by Equipment Supplier.

C. Equipment and accessories excluded from this Contract and to be provided by others include, but are not limited to:

1. Transformer and switchyard equipment

2. External piping, except as otherwise specified.

3. External electrical connections throughout and all alarm, signal and electrical devices except those specified to be furnished.

4. Balance of plant electrical and mechanical equipment and devices, except as otherwise specified.

D. Field office at the site to be used for all the Work of this Contract during field supervision and testing.

1.6 PROCUREMENT DOCUMENTS

E. One set of Specifications and pdf copies of Drawings will be furnished without charge to the Equipment Supplier. Additional sets will be furnished upon request at the cost of reproduction.

F. Drawings: the Work shall conform to the Drawings listed in the Table of Contents, all of which form a part of the Procurement Documents.

G. The Drawings issued with the Procurement Documents shall not be considered as defining the design of the Goods to be furnished, but rather to illustrate the general desired equipment arrangement, and any limiting or mandatory dimensions and elevations. Modifications to the powerhouse design can be made as necessary to accommodate Equipment Supplier's equipment and auxiliary systems and devices within the limitations specified in Section 01300 and Conditions of the Contract. All such modifications shall be subject to Engineer review and approval.

H. All proportioning and detailing of the Goods furnished under this Contract shall be performed by the Equipment Supplier in accordance with specified standards; however, dimensions shown on Drawings as mandatory shall be maintained.

I. Shop Drawings and Product Data submitted by Equipment Supplier and reviewed and accepted by the Engineer shall be considered supplementary to the Procurement Documents.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 01060
CODES, STANDARDS AND SPECIFICATIONS

PART 1 - GENERAL

1.01 GENERAL

A. The standards under which the Work shall be executed are specified throughout the Contract Documents. Where such standards are specified, it shall be understood that the latest revision or edition at time of submission of bids shall apply.

B. Other standards may be substituted for those specified, provided prior approval is obtained from the Engineer. If the Equipment Supplier desires to deviate from the specified or approved standards, a statement of the exact nature of and justification for the proposed deviation shall be submitted for approval.

C. In referring to standards the following abbreviations have been used:

Name	Abbreviation
American Association of State Highway & Transportation Officials	AASHTO
American Concrete Institute	ACI
American Institute of Steel Construction	AISC
American Institute of Timber Construction	AITC
American Iron and Steel Institute	AISI
American National Standards Institute	ANSI
American Petroleum Institute	API
American Plywood Association	APA
American Public Works Association	APWA
American Society for Testing and Materials	ASTM
American Society of Civil Engineers	ASCE
American Society of Heating, Refrigerating, and Air Conditioning Engineers	ASHRAE
American Society of Mechanical Engineers	ASME
American Water Works Association	AWWA
Architectural Woodwork Institute	AWI
American Welding Society	AWS
American Wood Preservers Bureau	AWPB
Associated General Contractors of America	AGC
Concrete Plant Manufacturers Bureau	CPMB

Concrete Reinforcing Steel Institute	CRSI
Federal Specification Board	U.S. Fed. Spec., Mil. Spec.
Institute of Electrical and Electronics Engineers, Inc.	IEEE
Insulated Power Cable Engineers' Association	ICEA
International Electro Technical Commission	IEC
Joint Industrial Council	JIC
Manufacturer's Standards Society	MSS
National Bureau of Standards	NBS
National Association of Corrosion Engineers	NACE
National Electrical Code	NEC
National Electrical Manufacturers Association	NEMA
National Fire Code	NFC
National Fire Protection Association	NFPA
National Forest Products Association	NFPA
Occupational Safety and Health Administration	OSHA
Society of Automotive Engineers	SAE
Steel Structures Painting Council	SSPC
Underwriters Laboratories	UL
Uniform Building Code	UBC
Uniform Mechanical Code	UMC
Uniform Plumbing Code	UPC
Western Wood Products Association	WWPA

D. Additional abbreviations will be defined as they appear in the specifications.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

Not applicable.

END OF SECTION

SECTION 01200
PROJECT MEETINGS

PART 1 - General

1.01 PROJECT KICKOFF MEETING

A. Within 14 days after Equipment Supplier receives Notice to Proceed, a kickoff meeting will be held at the location, date and time to be designated by the Owner. Equipment Supplier representatives shall attend.

1.02 PROJECT DESIGN REVIEW MEETINGS

A. During the execution and through the completion of the project design by the Equipment Supplier, there will be monthly design review meetings. At a minimum, these meetings will be attended by the Equipment Supplier, the Owner, and the Owner's Engineer.

B. During the execution, there will be a biweekly meeting for the project coordination with the Equipment Supplier to review the schedule and overall project status. The frequency of the meeting shall be adjusted as per the need and progress.

PRECONSTRUCTION CONFERENCE

C. A separate contract will be awarded for construction of the project. Within 28 days before the Contractor's scheduled date for start of construction, a preconstruction conference will be held at the location, date and time to be designated by the Owner. Contractor and his major subcontractors shall attend. The Equipment Supplier will be required to attend the Preconstruction Conference.

D. Agenda: The matters to be discussed at the Preconstruction Conference include:

1. Owner-furnished equipment supplied under the Procurement Contract
2. Construction schedule and progress reports to be submitted by Contractor.
3. Communication and general correspondence procedures between the parties.
4. The names and titles of all persons authorized by the Contractor to represent and execute documents for the Contractor with samples of all authorized signatures.
5. The names, addresses and telephone numbers of all those authorized by the Contractor to act in emergencies.
6. Access and rights-of-way furnished by the Owner.
7. Procedures for Contractor's submittals.
8. Construction equipment and methods proposed by the Contractor. The Contractor shall submit a list of equipment to be used in the Work.

9. Other administrative and general matters as needed.
10. Traffic movements on existing roads and parking areas for the public and Contractor.
11. Survey layout.
12. Emergency telephone numbers for doctors, hospital, ambulance service, etc.
13. Site and construction plant layout. Location of field office.
14. Temporary power and phone system.
15. Subcontractors.
16. Safety regulations as required
17. Progress payments, estimates and submittals for payment.

PART 2 - PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

Not applicable.

END OF SECTION

SECTION 01300
SUBMITTALS

PART 1 - GENERAL

1.01 SCOPE

A. This section describes the requirements for and procedures to be followed in submitting all samples, drawings, documents and other information and materials in connection with the performance of the Contract.

B. Related Work in Other Sections:

1. Section 01310 - Project Schedule and Coordination of Contract.
2. Section 01720 - Project Record Documents.

1.02 SUBMITTAL SCHEDULE

A. The Equipment Supplier shall, within 20 days after receiving the Notice to Proceed, prepare and submit for review an overall project submittal schedule, including list of design, shop drawings, calculations, and all other submittals, as required by Section 01310 – Project Schedule and Coordination of Contract. The overall project submittal schedule shall include a detailed list of all the individual submittals which the Equipment Supplier proposes to make to meet the requirements stated herein and those cited in other sections of the Specifications, together with the dates on which the Equipment Supplier proposes to make such submittals. The list shall include Shop Drawings, Manuals, Project Record Documents, and all other items for which a submittal is required. The list shall include identifying references for each item to relate it to the specific section of the Specifications.

B. It is imperative that the drawings be furnished within the time required herein, for the design of related facilities may be progressed on schedule.

C. After the submittal schedule is reviewed by the Owner or Owner's Engineer, it shall become the basis for the submittal of all items by the Equipment Supplier.

1.03 SUBMITTAL REQUIREMENTS

A. General: The Equipment Supplier shall furnish for review its submittals as outlined herein. The sequence of submission shall be such that information is available for review of each submittal when it is received. Drawings and schematics shall not be of typical equipment, but shall accurately represent the actual proposed equipment. All submittals shall bear an approval stamp or a certification. The stamp or certification shall be signed by an authorized representative of the Equipment Supplier. The Equipment Supplier's stamp or certification on any submittals shall constitute a representation to the Owner and the Owner's Engineer that the Equipment Supplier has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers and similar data, or that the Equipment Supplier assumes full responsibility for doing so, and that the Equipment Supplier has reviewed or coordinated each submittal with the requirements of the Contract Documents. Before submitting any drawings for review, the Equipment Supplier shall obtain approval of the list of drawings and calculations the Equipment Supplier proposes to submit, showing sequence of submittal and submittal dates. All drawings, calculations and other documents shall be submitted in accordance with the approved schedule specified in Paragraph 1.02, Submittal Schedule.

B. All submittals shall be in PDF format and compatible with Adobe Acrobat formatting. Drawing and Document numbering shall be as per Owner's standard. The numbering and filename convention will be provided to the Equipment Supplier after the project kick-off meeting. An AutoCAD title block template will also be provided by the Owner that must be used for creating all the project drawings. Drawings shall be in AutoCAD version (2020 or later).

C. Submittal drawings, cutsheets, reports, product data, etc. shall be submitted individually for approval for more efficient processing of submittals.

D. The drawings shall fully demonstrate that the equipment to be furnished will comply with the provisions of these Contract Documents and shall furnish a true and complete record of the equipment as manufactured and delivered. Additional drawings, instructions, or information which may be requested by the Owner or Owner's Engineer for erection, operation, and maintenance of the equipment or to determine compliance with the Agreement shall likewise be submitted for review. Review of the Equipment Supplier's drawings by the Owner or their designated representative shall not relieve the Equipment Supplier of the responsibility to meet all the requirements of these Contract Documents and correct detail and fit of parts when installed, or of the responsibility for the correctness of the drawings furnished by the Equipment Supplier. The Equipment Supplier shall have no claim for additional costs or extension of time on account of delays due to revisions of the drawings which may be found necessary to comply with the Contract Documents. In case of later discovery of errors, omissions, or inconsistencies in the Equipment Supplier's drawings, the Equipment Supplier shall promptly make any necessary corrections and submit revised drawings to the Owner or Owner's Engineer for re-review.

E. The Equipment Supplier's drawings shall have a blank area of 4 x 4 inches adjacent to the drawing title block for the Engineer's review stamp. Submittals shall be electronic submittals in pdf-file format. Electronic review and edits to the submittals would then be made and the submittal returned to the Equipment Supplier. Record copies of all approved, final submittals will be hard copies, plus electronic files.

F. All submittals shall be written in the English language and shall be fully legible.

G. All submittals shall be addressed to the Owner.

H. Each submittal shall be accompanied by a transmittal letter, which describes the items being submitted. The transmittal letter shall be clearly labeled Pine Flat Unit 4 Project and shall have a serial number. The first submittal shall have serial number 001, and subsequent submittals shall be consecutively numbered. Resubmittals of previously submitted information shall bear the same serial number as the initial submittal with a sequential alpha character as a suffix. For example, the second resubmittal of the submittal 001 shall be 001-A and the second resubmittal shall be 001-B, and so on.

1.04 REVIEW OF DRAWINGS AND DOCUMENTS

A. All review drawings shall be complete with title, drawing number, and dated.

B. The Owner or Owner’s Engineer review procedures shall apply to each revision of each submittal transmitted to the Owner or Owner’s Engineer. Within 30 calendar days after receipt of drawings for review, or as required to complete the review, one copy of each will be returned to the Equipment Supplier designated "No Exception Noted", "Corrections Needed", "Rejected", or "Not Required".

C. If a drawing is designated "No Exceptions Noted", the Equipment Supplier may proceed with the work in accordance with the drawing. If the Owner or Owner’s Engineer does not respond within 30 calendar days, the Equipment Supplier shall not be relived from correcting any defects found in those submittals upon review.

D. Every drawing designated “Corrections Needed” shall be corrected by the Equipment Supplier and resubmitted within 14 calendar days after Equipment Supplier’s receipt of that drawing. If a drawing is designated "Corrections Needed" and the Equipment Supplier incorporates the corrections identified during the review into the drawing, it may, at its own risk, proceed with the work covered by the corrected drawing. If a drawing is designated "Corrections Needed" and the Equipment Supplier does not incorporate the corrections identified during the review into the drawing, the drawing shall be considered designated “Rejected” as specified herein.

E. If a drawing is designated "Rejected," the Equipment Supplier shall revise the drawing to comply with the requirements of the Contract Documents and shall resubmit the drawing for review within 10 calendar days after Equipment Supplier’s receipt of that drawing. The Equipment Supplier shall not proceed with the work until a drawing is designated either "No Exceptions Noted" or "Corrections Needed."

F. Every revision shall be shown by number, date and subject in a revision block, and in addition, each revised drawing shall have its latest revision clearly indicated by clouding around the revised areas on the drawing. Drawings submitted without these indications will be considered nonconforming.

G. If a drawing is designated "not required," it is not required under the Agreement and its submittal shall be considered as for information only.

H. Revised drawings shall be submitted in the same size as the original submittal.

I. If the drawings contain information which does not pertain to the Agreement, the Equipment Supplier shall either delete the information which is not applicable or plainly identify the pertinent information.

J. No revision in any way shall be made after a drawing has been marked "no exceptions noted" without resubmitting the drawing for review.

K. The applicable parts of the requirements specified above for drawings shall apply equally to design data, calculations, catalog cuts, illustrations, printed specifications, draft reports or any other submittal furnished for review.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.01 REVIEW DRAWINGS AND DOCUMENTS

A. General: The Review Drawings shall be complete with title, drawing number, and date.

3.02 FINAL DRAWINGS

A. Signature of the Equipment Supplier

1. The Equipment Supplier shall complete and sign the drawings (and other documents) after review, with No Exceptions Noted, or after the revised drawings, with corrections made or resolved after review.
2. The final drawings (and other documents) shall be marked in the revision block with the word "Final".(Note: if Equipment Supplier does any site work, then Equipment Supplier will have to maintain running as-built markups on-site, and provide final as-built revisions of drawings.)

3.03 SIGNATURE OF REGISTERED ENGINEERS

A. All original construction and installation, equipment mounting and support, and seismic drawings, design drawings, supporting calculations, engineering analyses and reports shall be signed and sealed by the applicable professional Civil, Electrical, Mechanical, or Structural Engineer registered in the State of California.

3.04 SIGNED DRAWINGS AND DOCUMENTS

A. After drawings are signed and dated, the Equipment Supplier shall provide the Owner pdf and original format copies by uploading them to SharePoint drive. The original design drawings shall be in AutoCAD format (2020 version or later) while all other documents shall be in MS Word, MS Excel, MS Project and other Microsoft applications, as applicable. Original calculations done in ETAP, EasyPower, MathCAD, etc shall also be submitted in their original format along with their associated database files.

3.05 DRAWING REVISIONS

A. The Equipment Supplier shall make revisions needed to correct the drawings for all errors or omissions which may be found by the Owner or Owner’s Engineer. A brief description of all such revisions shall be made by the Equipment Supplier in the revision block area of the drawings. The review and signatures of revisions shall be handled the same as for the original drawing, except that signatures shall be by initials only. Revisions shall be raised numerically with each successive revision, with the original submittal marked as Revision-0 (zero). Each revision shall be identified on the drawing by clouding or similar means.

END OF SECTION

SECTION 01310
PROJECT SCHEDULE AND COORDINATION OF CONTRACT

PART 1 - GENERAL

1.01 DESCRIPTION

Scope: This section covers Project construction schedule restrictions, Project Schedule submittals, coordination of Work with that of others, and required completion dates.

1.02 PROJECT SCHEDULE

A. KRCD applied for a licensed amendment of the existing Pine Flat license with FERC to include the addition of Unit-4. The application was filed in December, 2021 and all the necessary hearings and paperwork have been completed as of the posting of this specification. The license amendment approval is expected by end of 2022 or early 2023. KCRD shall notify all the stakeholders and contractors/ suppliers of the approval.

B. Commencement of Powerhouse Construction shall not begin prior to obtaining all applicable permits and regulatory authorization.

1.03 COMBINED DESIGN, FABRICATION AND DELIVERY SCHEDULE

A. Within 20 days after issuance of the Notice to Proceed, the Equipment Supplier shall submit for Owner and Owner's review a combined design, fabrication and delivery schedule, including design, shop drawing development, material procurement, fabrication, machining, shop assembly, testing, shipping and delivery. Every month thereafter the Equipment Supplier shall revise the schedule and shall resubmit it to the Owner or Owner's Engineer for review. The latest revised schedule shall be submitted for discussion at the periodic meetings.

B. The schedule shall be a time-scaled network diagram prepared using the critical path method. The schedule shall clearly show each unit of Work to be performed under the Contract and all items involved in the overall sequencing of the Work.

C. The schedule shall be prepared and maintained using MS-Project scheduling software.

D. The project schedule shall be arranged with notations to show how the sequence of Work is affected by design, review, purchase of materials, fabrication time, and any other items deemed appropriate.

1.04 COORDINATION OF CONTRACTS

A. The work shall be coordinated with the following contracts, and any additional contracts which may be let:

1. A separate construction contract will be entered in to for the construction of the Powerhouse. Construction of the powerhouse will commence before equipment manufacture is complete and will require delivery of embedded parts before remaining equipment.

B. Equipment Supplier shall cooperate with other contractors and shall not hinder, delay or prevent other contractors from performing work. Portions of the use areas shown on the Drawings may be required for use by other contractors or the Owner.

1.05 REQUIRED COMPLETION DATES

A. The work is divided into specific milestones. The minimum requirements for completion of each milestone are defined below.

   1. Final submittal of all design drawings.
   2. Delivery of 1st stage embedded parts.
   3. Delivery of 2nd stage embedded parts.
   4. Delivery of all remaining parts.

B. Liquidated Damages:

In case of failure on the part of the Equipment Supplier to meet the required Milestone 2, Milestone 3, and Milestone 4, dates to be specified, or any extensions thereof, the Equipment Supplier shall pay to the Owner fixed and agreed to liquidated damages as specified in Agreement.

PART 2 - PART 2 - PRODUCTS

Not applicable.

PART 3 - PART 3 - EXECUTION

Not applicable.

END OF SECTION

SECTION 01320
PROGRESS REPORTS

PART 1 - GENERAL

1.01 DESCRIPTION

A monthly progress report shall be submitted to the Owner or Owner's Engineer in a form approved by the Owner or Owner's Engineer. The progress report shall be submitted by the Equipment Supplier together with its Application for Payment, in accordance with Article 7- Payment Procedures, of the Agreement. At a minimum, the monthly progress report shall include high level of details of:

A. Progress of Work: Provide a brief narrative description of design, procurement, fabrication, testing and transport activities and related events during the report period. Report major items of work which reflect overall progress, rather than detailed statistical information.

B. Status of Equipment: Furnish major equipment manufacturing schedules and progress chart.

C. Contract Status: Identify principal subcontractors engaged on the work. Describe any special expertise or equipment possessed by subcontractors. Show changes monthly.

D. Critical Events and Dates: Report important items and events such as design progress, completion of design, manufacturing progress, shop testing, assembly inspections, and delivery of equipment.

END OF SECTION

SECTION 01400
QUALITY ASSURANCE

PART 1 - GENERAL

1.01 GENERAL

In addition to the provisions in the Conditions of Contract, the following shall apply.

1.02 RELATED REQUIREMENTS SPECIFIED ELSEWHERE

A. Submittals: Section 01300

PART 2 - PRODUCTS

Any materials, supplies or articles required in the Work which are not covered by detailed specifications herein shall be standard products of reputable manufacturers and suitable for the intended use. Unless specifically required or so directed, tests of these items will not be required but such items will be subject to the acceptance of the Engineer. Tests, if directed, shall be in conformity with approved modern methods for the particular item and class of work.

All parts shall be made to standard gauge where possible, and like parts shall be interchangeable.

2.01 GENERAL

Whenever in these Specifications references are made to published standards or requirements, it shall be understood that the latest standards or requirements of the respective issuing agencies which have been published as of the date proposals are invited for the Work shall apply, unless otherwise specified herein, except to the extent that said standards or requirements may be in conflict with applicable laws, ordinances or governing codes. No requirement set forth in these Specifications or shown on the Drawings shall be waived because of any provision of, or omission from said standards or requirements.

2.02 ALTERNATIVE STANDARDS

The Equipment Supplier may request that, for articles manufactured outside the United States, alternative technical standards in force in the country of origin shall apply. Such request will be considered by the Engineer upon receipt of written application by the Equipment Supplier, including the following information:

A. The part or parts of the Work affected.

B. Justification for the requested change.

C. Complete details of the alternative standard proposed, expressed in the English language and U.S. customary units of measurement.

D. Information demonstrating the material or equipment conforming to the proposed alternative standard will be equal or superior in quality, durability and suitability for the intended use to that conforming with the reference standard cited in the Specifications.

2.03 MANUFACTURER REQUIREMENTS

All manufacturers who furnish materials or equipment for the Work shall comply with the following requirements. The Equipment Supplier shall, before placing orders for or undertaking manufacture of items of the Work, submit information to the Engineer demonstrating that the requirements are met:

A. Each manufacturer shall be experienced in the manufacture of the class, size and rating of the various components specified herein. Previous manufacturing experience and present manufacturing facilities will be considered, together with information as to the type, size, location and service experience recorded of similar equipment previously furnished, in determining whether the manufacturer is qualified to perform the Work.

B. Each manufacturer shall have the necessary capital and experience, and own, control by firm option, or be able to procure the necessary plant to commence the Work promptly upon award, and thereafter prosecute and complete the Work within the time specified. Manufacturers shall not be already obligated for the performance of other Work which would delay the commencement, prosecution and completion of the Work contemplated herein.

C. Each manufacturer shall have available and maintain within the contiguous United States an adequate supply of spare parts and an organization capable of promptly making necessary replacements or repairs to or alterations of the equipment the manufacturer proposes to furnish.

PART 3 - EXECUTION

3.01 QUALITY CONTROL SYSTEM

A. The Equipment Supplier shall provide a quality control organization and system to perform inspections, tests and retesting in the event of failure of all items of Work, including that of subcontractors, to assure compliance with the Contract provisions.

B. Prior to the start of manufacture, the Equipment Supplier shall submit to the Engineer a plan detailing the organization, procedures and reports to be used to assure compliance of the Work with the requirements of the Contract.

C. All submittals, working drawings, catalog cuts, samples, etc., unless otherwise specifically noted, shall be approved and certified by the Equipment Supplier as conforming to the Contract Documents. All test results provided shall cite the specific Contract requirements the results satisfy and shall include the test or analysis procedures used, the actual test results, and a statement that the item tested or analyzed conforms or fails to conform to the Specification requirements.

D. Throughout the period of the Contract, the Equipment Supplier shall make available all reports, test results and other documentation of the quality control organization relating to the Work, for inspection by the Engineer.

3.02 INSPECTION AND TESTS

Unless waived in writing, all tests and trials conducted relating to the turbine, generator, turbine shutoff valve, governor, hydraulic power unit (HPU), switchgear and controls, piping and all other equipment to be furnished under this contract shall be made in the presence of an inspector and a copy of all test reports showing the results thereof shall be furnished to the Engineer. All other test results shall be made available for inspection by the Engineer at the Equipment Supplier's facility.

Any deficiencies noted during the Factory tests shall be repaired at the manufacturer's/ supplier's own cost and that no equipment shall ship until the quality report is fully approved by the engineer and given approval to ship.

END OF SECTION

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SECTION 01720
PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. At the beginning of the Work, the Equipment Supplier shall set aside one complete set of prints of the Reference Drawings, Contract Drawings, Supplier's design drawings, and any later supplementary drawings, upon which shall be recorded all deviations in manufacturing and construction and all deviations due to Change Orders. Notations and changes shall be done with a red pen in a neat and legible manner as prescribed by the Engineer. At any time during normal working hours, the Equipment Supplier shall make the Record Drawings available to the Engineer to examine and verify that they are being kept up to date. Upon completion of the project, the Equipment Supplier shall deliver a complete set of Contract Drawings, Supplier's design drawings and supplementary drawings showing and annotating the as-built conditions, and the set of marked-up Reference Drawings showing as-built conditions, including any changes during installation and commissioning to the Engineer and Owner before final payment will be made.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

NOT APPLICABLE

END OF SECTION

SECTION 01730
OPERATIONS AND MAINTENANCE DATA

PART 1 - GENERAL

1.01 SCOPE OF WORK

The Equipment Supplier shall compile and submit operating and maintenance data for all mechanical and electrical equipment provided under the Contract, including parts lists of all components, as well as a recommended spare parts list.

1.02 RELATED REQUIREMENTS SPECIFIED ELSEWHERE

A. Submittals - Section 01300

B. Warranties and Guarantees - Section 01750

1.03 QUALITY ASSURANCE

A. Preparation of data shall be done by personnel which are:

1. Trained and experienced in maintenance and operation of the described products.
2. Completely familiar with requirements of this Section.
3. Skilled as technical writers to the extent required to communicate essential data.

1.04 SUBMITTAL REQUIREMENTS

A. One (1) digital pdf copy of sample data format and outline of contents in draft form shall be submitted prior to delivery of the equipment to be installed in the power plant.

B. One (1) digital pdf copy of a complete draft of the data with catalogs and drawings shall be submitted to the Engineer for review. One draft copy will be returned with comments. The Equipment Supplier shall resubmit the one draft copy with such corrected and/or additional data sheets and drawings as may be required.

C. Upon final approval of the draft, the Equipment Supplier shall prepare three hard copies and furnish them and a digital pdf copy of the same to the Engineer within 30 days of final approval.

PART 2 - PRODUCTS

2.01 FORMAT OF MANUALS

A. Three sets of manuals are required along with a pdf copy of the same manual.

B. Data shall be provided in book form, completely assembled and delivered to the Engineer at one time. All data shall be in one volume, if possible.

C. Provide expandable binders with project name and volume number engraved on front and spine of binder. Thermofax copies and ring binders are not acceptable.

D. A separate master index shall be provided for each volume required. Reduced size drawings shall be provided folded and bound for easy unfolding without removal from the binding. Each sheet in the binder shall be numbered and an index provided for ready reference to the data.

E. All standard catalog cuts, manufacturer's printed data or descriptive literature, parts sheets, illustrations, etc., shall either be original sheets provided by the manufacturer, or reproduced copies of equal clarity and durability.

F. Folded page size shall be 8-1/2 inches by 11 inches. Paper shall be 20-pound minimum stock.

G. A fly-leaf shall be provided between pages relating to different products or components, with a printed or typed description of the product or component to which the succeeding pages refer.

H. Index tabs shall be provided.

I. A complete copy of all O&M Manuals shall be submitted as a Adobe PDF file via a SharePoint or other suitable method.

2.02 CONTENT OF MANUALS

A. OPERATING AND MAINTENANCE MANUAL: Each set of manuals shall include the following:

1. General titles:
   a. Pine Flat 4th Unit-4 Hydroelectric Project Operation and Maintenance Manual.
2. Project identification.
3. Identification of system or equipment.
4. Table of contents and index.
5. Name, address and telephone numbers of Equipment Supplier and of all equipment manufacturers.
6. Name, address and telephone numbers of manufacturers' nearest service representatives.
7. Description of systems and components.
8. Pre-operation checks and inspection lists.
9. Procedures for starting, operating and stopping equipment.
10. Post-operation check or shut-down lists.
11. Special and emergency operating instructions.
12. Accepted test data.
13. Routine maintenance procedures and schedules.
14. Complete disassembly and reassembly instructions, with illustrations.

15. Manufacturers' printed operating and maintenance instructions, and manufacturers' parts lists, parts numbers, illustrations (illustrated breakdowns) and diagrams.
16. One copy of each schematic diagram.
17. One copy of each wiring diagram.
18. One copy of each final assembly drawing.
19. Matchmarking information, and identification of locations where metric bolting warning nameplates are affixed.
20. List of spare parts, and manufacturers recommended quantities.
21. Names, addresses and phone numbers of nearest parts vendors.
22. Copies of warranties issued to, and executed in the name of the Owner, in accordance with Section 01750.

B. PARTS LISTS

1. Parts lists and catalogs shall include the part identification, nomenclature, part numbers, required number of parts and actual spare parts supplied.
2. All data shall match the actual equipment furnished, and standard catalog sheets, cuts and diagrams shall have all irrelevant parts marked out.
3. Parts shall be so identified that they can be readily ordered.
4. Assembled material shall be completely indexed and include identification of spare parts furnished in compliance with requirements of these Specifications.
5. A cross-reference between items described in catalogs and instructions and drawings shall be provided to facilitate location of parts described.

C. OPERATIONS AND MAINTENANCE DATA OF OTHERS

1. The Equipment Supplier shall include operations and maintenance information from all sub-suppliers.
2. Equipment Supplier shall integrate O&M data from all equipment suppliers and subsuppliers into a single comprehensive O&M Manual.

PART 3 - EXECUTION

3.01 INSTRUCTION OF OWNER'S PERSONNEL

A. Prior to final inspection or acceptance, the Equipment Supplier's Representative shall fully instruct the Owner's designated operating and maintenance personnel in the operation, adjustment and maintenance of all products, equipment and systems. The instruction shall be in English language and equipment details shall be specific to the project. A generic instruction is not acceptable.

B. The operating and maintenance manuals shall constitute the basis of instruction. The Equipment Supplier’s Representative shall review the contents of the manual with the Owner's personnel in full detail to explain all aspects of operation and maintenance.

C. The instruction shall be conducted on-site.

END OF SECTION

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SECTION 01750
WARRANTIES AND GUARANTEES

PART 1 - GENERAL

1.01 SCOPE OF WORK

This section covers warranties and guarantees required of the Equipment Supplier.

1.02 RELATED REQUIREMENTS SPECIFIED ELSEWHERE

A. General Conditions.

B. Supplementary Conditions.

C. Operating and Maintenance Data - Section 01730.

1.03 TURBINE PERFORMANCE GUARANTEE

A. Within the warranty period, Owner may, at its option and expense, perform an efficiency test of the turbine to verify that the efficiency guarantees have been fulfilled. The efficiency or field performance test, if performed, will be conducted in accordance with ASME Power Test Code 18.

B. If the field performance test indicates that the efficiency guarantees have been met, the Owner will pay for the test. If, however, the field performance test indicates that the efficiency guarantees have not been met (without inclusion of any measurement inaccuracies or error bands), then the Equipment Supplier shall pay for the test and shall correct the defect in performance.

C. The performance test will be performed under the direction of a qualified independent expert acceptable to both the Equipment Supplier and the Owner.

1.04 TURBINE CAVITATION PITTING GUARANTEE

A. The turbine shall operate over the entire range of operating heads and flows as provided with the turbine manufacturers bid without surging, rough operation, or excessive cavitation.

B. Excessive cavitation shall be defined as a condition that results in pitting of the turbine runner, discharge ring and draft tube liner and results in removal of metal or which exceeds the limits stated herein and/or is measurably detrimental to power and efficiency of the turbine.

C. Equipment Supplier shall guarantee that the removal of metal from the runner, discharge ring and draft tube due to cavitation shall not be in excess of:

1. The removal of metal at a rate in excess of:

   $0.1D^2/8000$ lbs. per operating hour,

where D= diameter of runner in feet

2. The removal of metal to a depth exceeding 0.125 inches over an area or sum of areas equal to or greater than one square inch or greater.

3. This guarantee shall be based on not operating the unit in excess of 100 percent full load rating for more than 10 percent of the total operating time; or at less than the minimum gate for guaranteed continuous stable operation, for more than 10 percent of the total operating time.

4. Erosion and damage caused by suspended matter in the water, or corrosion caused by chemical composition of the water, are not intended to be covered by the pitting guarantee.

D. The method of determining quantity of metal removed due to cavitation shall be in accordance with the recommendations of the International Electro-Technical Commission (IEC) Publication 609.

E. Repair of Cavitation Damage.

1. If excessive pitting due to cavitation occurs during the warranty period, the damaged surfaces shall be restored to original contours by welding with stainless steel and grinding and blending to smooth surfaces flush and equal in finish to the undamaged surfaces surrounding the repair. The repair shall include all areas where the depth of pitting exceeds 0.125 inches.
2. In all cases of local cavitation damage originated or aggravated by any contour errors, the necessary modifications in the turbine parts shall be made to prevent its recurrence.
3. For cavitation repairs, Owner will dewater the turbine to the extent necessary at a mutually convenient time and will provide proper access to the work. Equipment Supplier shall furnish and bear all costs for labor, materials, and equipment required for the repairs.
4. The pitting guarantee shall be renewed and extended for a period of 8,000 operating hours after any repairs or modifications due to excessive pitting. Should excessive pitting occur again during the renewed guarantee period, Equipment Supplier shall again repair the resulting damage and renew the pitting guarantee for an additional 8,000 operating hours. This cycle shall continue until Equipment Supplier makes modifications which allows the turbine to operate 8,000 hours without excessive pitting, as defined above, or until four repair cycles have occurred.

1.05 MANUFACTURERS' WARRANTIES

A. All equipment, including sub-assemblies and individual components under the scope of supply shall have Twelve (12) month warranty for any defects and/or malfunctioning. The warranty date shall begin on the Scheduled Full Operation Date. Any cost associated with the repair, replacement or other action taken by the equipment supplier within the 12 month warranty period shall be borne by the equipment supplier.

B. All warranties which are available in the normal course of business from manufacturers of equipment or components, such warranties shall be obtained by the Equipment Supplier and furnished to the Owner as follows:

1. Assemble warranties from manufacturers and subcontractors.
2. Provide two signed original copies.
3. Provide a Table of Contents, neatly typed, in orderly sequence. Provide the following information for each item:
    a. Product or work item.
    b. Manufacturer, with name of principal, address and telephone number.
    c. Scope.
    d. Date of beginning of warranty.
    e. Duration of warranty.
    f. Proper procedure in case of failure.
    g. Instances which might affect the validity of warranty.
    h. Include as part of the operation and maintenance data per Section 01730.

1.06 RIGHT TO OPERATE UNSATISFACTORY EQUIPMENT

The Owner shall have the right to operate any and all equipment as soon as, and as long as, it is in operating condition whether or not such equipment has been accepted as complete and satisfactory, except that this shall not be construed to permit operation of any equipment which may be materially damaged by such operation before any required alterations or repairs have been made.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION

SECTION 05000

MATERIALS AND WORKMANSHIP

PART 1 GENERAL

1.01 DESCRIPTION

A. This section covers requirements for material, workmanship, welding, nondestructive testing (NDT) methods, and acceptance standards for various types of metalwork used in the contract.

B. This section is intended for general use. Not all requirements in the section may be used in this Contract.

1.02 RELATED SECTIONS

A. Supplementary General Conditions, General Conditions, Division 1 sections, and Drawings apply to this section. This section may require direct correlation with the following sections of the Contract:

1. Section 01300 - Submittals
2. Section 11500 - TSV
3. Section 11510 – TSV Operator
4. Section 15645 – Hydraulic Turbine
5. Section 15970 – Turbine Governor
6. Section 15980 – HPU
7. Section 09970 - Coatings

1.03 REFERENCES

A. The following publications form a part of this specification to the extent referenced. Application of these publications shall conform to Document 00702 – Interpretation of the Contract, Paragraph 2:

1. American National Standards Institute (ANSI):
   a. ANSI B1.1 – Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms).
   b. ANSI B46.1 – Surface Texture (surface roughness, waviness, and lay).
2. American Society of Mechanical Engineers (ASME):

a. BPVC – Boiler and Pressure Vessel Code.

3. American Society for Nondestructive Testing, Inc. (ASNT):

   a. SNT-TC-1A – Personnel Qualification and Certification in Nondestructive Testing.

4. American Society for Testing and Materials (ASTM):

   a. ASTM A 123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

   b. ASTM A 153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

   c. ASTM A 370 – Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

   d. ASTM A 380 – Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.

   e. ASTM A 388 – Standard Practice for Ultrasonic Examination of Steel Forgings.

   f. ASTM A 609 – Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof.

   g. ASTM A 743 – Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

   h. ASTM A 780 – Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

   i. ASTM A 802 – Standard Practice for Steel Castings, Surface Acceptance Standards, Visual Examination.

   j. ASTM B 824 – Standard Specification for General Requirements for Copper Alloy Castings.

   k. ASTM E 94 – Standard Guide for Radiographic Examination Using Industrial Radiographic Film.

   l. ASTM E 114 – Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing.

   m. ASTM E 125 – Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings.

n. ASTM E 165 – Standard Practice for Liquid Penetrant Testing for General Industry.

o. ASTM E 186 – Standard Reference Radiographs for Heavy-Walled (2 to 412 in. (50.8 to 114 mm)) Steel Castings.

p. ASTM E 272 – Standard Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Alloy Castings.

q. ASTM E 446 – Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness.

r. ASTM E 488 – Standard Test Methods for Strength of Anchors in Concrete Elements.

s. ASTM E 515 – Standard Practice for Leaks Using Bubble Emission Techniques.

t. ASTM E709 – Standard Guide for Magnetic Particle Testing.

5. American Welding Society (AWS):

a. AWS A2.4 – Standard Symbols for Welding, Brazing, and Nondestructive Examination.

b. AWS A3.0 – Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.

c. AWS A5.1 – Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.

d. AWS A5.4 – Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding

e. AWS A5.5 – Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding.

f. AWS A5.9 – Specification for Bare Stainless Steel Welding Electrodes and Rods.

g. AWS A5.22 – Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding.

h. AWS D1.1 – Structural Welding Code – Steel.

i. AWS D1.2 – Structural Welding Code – Aluminum.

j. AWS D1.3 – Structural Welding Code - Sheet Steel.

k. AWS D1.6 – Structural Welding Code-Stainless Steel.

1.04 SUBMITTALS

A. Submit the following:

1. Welding Procedure Specifications (WPS) and Welding Procedure Qualification Records (WPQR) test results.

2. Welding preheating procedures.

3. Welding assembly sequence.

4. Welding repair procedures.

5. Electrodes for welding steel, stainless steel, and aluminum.

6. Nondestructive testing procedures for each method proposed for the work.

7. A technique radiograph shot to demonstrate ability to produce an acceptable radiograph, as specified in Paragraph 2.05 B.3.d, prior to radiographic testing.

8. Working drawings showing details of weldments to be stress relieved.

9. Stress relief heat treating procedures.

10. Solution heat treatment procedures.

11. Passivation procedures.

12. Project specific Quality Assurance Plan (QAP).

13. Quality control program and procedures manual.

14. Lubricant for stainless steel threads.

15. Material lists.

16. Certified Material and Test Reports.

17. Material standards that differ from those specified.

18. Material standards for materials not specified.

19. Casting documents including casting process, working drawings, inspection, test, and repair procedures, and reports.

20. Illustrations showing location, depth and length of defects in the castings and the repair methods prior to starting repairs.

21. Forging documents including forging process, working drawings, inspection, test, and repair procedures, and reports.

22. Machining drawings including tolerances.

23. Schedule detailing inspections, NDT tests dates, and inspection hold points.

24. NDT reports.

1.05 QUALITY ASSURANCE

A. The Equipment Supplier shall ensure that materials and equipment specified in this contract are designed, manufactured, inspected, and tested as specified, as shown, and conforming to the Equipment Supplier's project specific QAP.

B. In case of conflicts, the Contract Specifications and Drawings shall govern over the QAP.

C. Elements of QAP:

   1. Elements of the QAP shall not conflict with the Contract Specifications, but may be in accordance with the existing documented quality system of the Equipment Supplier, the Equipment Supplier's suppliers, and manufacturers for the work to be provided.

   2. QAP shall define quality system elements, which apply to the Equipment Supplier's suppliers and manufacturers of equipment and materials.

   3. QAP shall address each phase of the work including design, manufacturing, testing, inspection, repairs, delivery, and installation.

D. The Equipment Supplier shall ensure compliance to each element of QAP for work performed by the Equipment Supplier, suppliers, and manufacturers by controlling and supervising casting, forging, fabrication, machining, coating, assembly, testing, and other production processes, where these activities are occurring in the Equipment Supplier's, suppliers', or manufacturers' facilities.

E. Pursuant to Document 00706 – Control of Work, the Equipment Supplier shall provide the Engineer:

   1. Access to offices and places of manufacture of the Equipment Supplier, suppliers, and manufacturers and technical coordination for the purposes of auditing QAP.

   2. Resources and materials required for auditing QAP.

F. The Engineer may elect to monitor the Equipment Supplier's methods, procedures, and processes to verify compliance with QAP.

1.06 PROPOSED SUBSTITUTIONS OR "OR-EQUAL" ITEMS

A. Whenever materials or equipment are indicated in the Contract Documents by using the name of a proprietary item or the name of a particular manufacturer, the naming of the item is intended to establish the type, function, and quality required. If the name is followed by the words "or equal" indicating that a substitution is permitted, materials or equipment of other manufacturers may be accepted if sufficient information is submitted by the Equipment Supplier to allow the Engineer to determine that the material or equipment proposed is equivalent or equal to that named, subject to the following requirements:

1. The burden of proof as to the type, function, and quality of any such substitution product, material or equipment shall be upon the Equipment Supplier.

2. The Engineer will be the sole judge as to the type, function, and quality of any such substitution and the Engineer's decision shall be final.

3. The Engineer may require the Equipment Supplier to furnish additional data about the proposed substitution.

4. The District may require the Equipment Supplier to furnish a special performance guarantee or other surety with respect to any substitution.

5. Acceptance by the Engineer of a substitution item proposed by the Equipment Supplier shall not relieve the Equipment Supplier of the responsibility for full compliance with the Contract Documents and for adequacy of the substitution.

6. The Equipment Supplier shall pay all costs of implementing accepted substitutions, including redesign and changes to Work necessary to accommodate the substitution.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The material requirements for the various types of Work shall be as specified herein and in each of the referenced related sections.

B. Where these specifications differ from the referenced specifications and codes, these specifications shall govern the work.

C. Where more than one material specification is listed for a particular item of the work, any of the material specification is acceptable.

D. All equipment and materials shall be brand new, of sound workmanship and robust field-proven design, and as far as practicable from standard production.

E. No materials shall be installed that are deleterious to Health and Safety, or to the longevity of the installation. At no point shall Equipment Suppliers install any, goods, materials, substances or products that are not in accordance with relevant regulations or otherwise generally known within the industry at the time of this specification. All materials and workmanship shall be in accordance with good building practices current at the time of installation.

F. The work shall also include all considerations such as safety requirements, minimum maintenance commitment, ease of operation and maintenance access etc. in order to obtain an overall efficient installation.

G. Insulated flanges, couplings or unions shall be provided between ferrous and nonferrous connections.

H. Fastening devices in contact with water shall be austenitic stainless steel, and threads shall be coated with an approved anti-seize compound.

I. Copper base, aluminum base, and other nonferrous alloys for parts in contact with water shall contain not more than five percent zinc and not more than two percent aluminum.

J. Flanges shall be welding neck type unless otherwise shown or as approved.

K. Elbows shall be long radius unless otherwise shown or as approved.

2.02 WORKMANSHIP

A. General:

1. Component parts shall be fabricated or manufactured to English system of units as used in United States.

2. Component parts for equipment or fabricated assemblies shall be of the same manufacture, material, workmanship quality, and shall be interchangeable.

B. Steel Fabrication:

1. Steel fabrication methods shall not destroy original properties of the material. Sharp kinks or bends in members will not be allowed. Bends shall be made by dies, bending rolls, or other approved methods. Bending equipment and material shall be cleaned prior to bending. Shaping by blows will not be allowed. Reentrant cuts on light metal shall be by shearing or by rectangular punch. Shearing shall be accurate and finished. Edges produced by cutting, shearing or punching shall be deburred. Corners shall be square unless otherwise approved. Edges to be coated shall be rounded to a 1/16 inch radius.

C. Tolerances:

1. Tolerances shall conform to applicable ANSI Standards or as approved. Tolerances shall be shown on the shop drawings.

D. Cutting:

1. Low carbon steel shall be cut by torches, shears, or saws. Flame cutting of materials other than low carbon structural steel will not be allowed unless approved. Flame cutting locations shall be shown on the working drawings. Cutting flame shall not overheat adjacent metal. An approved mechanical guide shall be used to guide path of torch. Torch cuts shall be chipped, ground, or machined to sound metal and shall be smooth, uniform, free of loose scale and slag accumulations. Edges to be welded shall be prepared conforming to AWS Codes specified in Paragraph 2.06, Welds and Welding. Other edges shall be smooth, free of notches and gouges and shall be rounded to a 1/16 inch radius.

E. Threaded Connections:

1. Thread class shall be Class 2 conforming to ANSI B1.1, except that Class 3 shall be provided in holes tapped for studs. Bolts and studs shall project neither less than 1/4 inch nor more than 1/2 inch through nut when drawn tight. Bolts, studs or cap screws in tapped holes shall provide an engaged length of threaded portion of fastener no less than nominal diameter of fastener in steel and no less than 1-1/2 times nominal diameter in cast iron or bronze. Bolt heads and nuts shall be hexagonal, except where special shapes are required and approved. Bolt, stud, or cap screw subjected to vibration or alternating stresses shall have self-locking element permanently embedded in threads or an equivalent approved means of locking.

2. Components fastened to studs shall be able to be assembled and disassembled without removing studs.

3. Thread sealers shall be applied to the threaded connections to prevent water or moisture retention between the threads.

F. Bolted Connections:

1. Holes for bolts shall be 1/16-inch larger than nominal diameter of bolt unless closer tolerances are shown or specified. Drilling and reaming shall be performed after parts are assembled. Slotted holes shall be made by machining. Bolt holes made by flame cutting will be rejected. Punching bolt holes in material exceeding ¾-inch thickness will not be allowed. Bolt heads and nuts shall bear on seats at right angles to centerline of bolts. Bolt holes shall be cylindrical and perpendicular to member unless otherwise shown or specified. Where thickness of the material is greater than nominal diameter of bolt, bolt holes shall be subpunched and reamed, subdrilled and reamed or drilled from the solid. Mismatching of bolt holes will be considered defective work and will be rejected. Welding to or on high strength bolts will not be allowed.

2. Enlargement or elongation of bolt holes during assembly will not be allowed.

G. Embedded Parts:

1. The Equipment Supplier shall furnish anchor bolts, sole plates, leveling bolts, and other appurtenances required for installation of the equipment. Embedded bolts shall have templates at top and bottom of bolts during placement of concrete. The Equipment Supplier shall furnish and use templates, working drawings, and written instructions for installation of the equipment. The Equipment Supplier shall verify setting of embedded parts before, during, and immediately after concrete placement.

H. Surface Finish:

1. Type of surface finish shall be shown on the working drawings in microinches in accordance with ANSI B46.1.

2. Type of surface finish shall be as follows:

   a. 32 microinches for bearing surfaces and contact surfaces of shafts which pass through seals.

   b. 63 microinches for surfaces in sliding contact.

   c. 125 microinches for surfaces in permanent contact for liquid-tight joint.

   d. 250 microinches for surfaces in permanent contact where a liquid-tight joint is not required and other machined surfaces.

2.03 CASTINGS

A. General:

1. The Equipment Supplier shall provide documents for each type of casting to include casting process; working drawings; and inspection, test, and repair procedures, and test reports as specified prior to final acceptance of the castings.

2. Net dimensions of castings shall be shown on the working drawings.

3. Patterns shall remain the property of the Equipment Supplier.

4. A minimum of two tensile test coupons shall be prepared for each casting. Test coupons shall be cast integrally, shall be of the identical material as the casting, and shall conform to ASTM A 370. Test coupons shall be machined to conform to standard specimen shown in ASTM A 370, Figure 5.

5. Test coupons shall be marked for identification to each casting. Test coupons shall accompany each casting throughout heat treatment processes and shall be tested after each heat treatment.

6. The Equipment Supplier shall notify the Engineer, in writing, of the proposed times of implementing casting, testing, and repair procedures.

Number of days of advance notice to be given for each procedure shall be as agreed upon by the Equipment Supplier and the Engineer.

7. The Equipment Supplier may propose equivalent standards to be used in lieu of the standards listed, only to be used upon approval by the Engineer.

B. Iron Castings:

1. Iron castings shall be visually inspected after removal from molds and after cleaning. Surfaces of iron castings shall be tested by magnetic particle testing. Cast Iron shall not be used for pressure containing parts.

2. Corrections or repairs of defective iron castings will not be accepted.

C. Carbon Steel Castings:

1. Carbon steel castings shall be normalized and tempered and shall include the following:

   a. Complete time/temperature history for castings, repair, and heat treatment processes.

   b. Heat treatment shall be performed in an electric or gas fired, fully baffled furnace. Heat treatment atmosphere shall not result in carburization, decarburization, or nitriding of the castings. Thermocouples shall be located on each casting to monitor temperature during the heat treatment and shall be shown on the working drawings.

   c. Test reports shall include chemical analysis and tensile test results.

D. Stainless Steel Castings:

1. Stainless steel castings shall include the following:

   a. Melting and mixing shall be followed by argon-oxygen-decarburization refinement or vacuum-oxygen decarburization refinement.

   b. Complete time/temperature history for casting, repair, and heat treatment processes.

   c. Heat treatment shall be performed in an electric or gas fired, fully baffled furnace. Heat treatment atmosphere shall not result in carburization, decarburization, or nitriding of the castings. Thermocouples shall be located on each casting to monitor temperature during heat treatment and shall be shown on the working drawings.

   d. Castings shall be supported on stainless steel or Inconel racks and fixtures or on silica firebrick.

e. Casting test reports shall include chemical analysis; gas analysis for hydrogen, oxygen, and nitrogen; tensile test results; and shall include the ferrite number of austenitic stainless steels. Analysis for carbon shall be performed from one stainless steel casting representative of each heat. Sample for the analysis shall be within 0.010 inch of surface and shall be taken after each heat treatment and after removal of scale and other surface contaminants. Carbon content shall conform to ASTM A 743, Table 2. The test reports are to be furnished prior to the final acceptance of the stainless steel castings.

E. Initial Inspection of Iron Castings, Carbon Steel Castings and Stainless Steel Castings:

1. Castings shall be inspected as follows:

a. Visually inspected after removal from molds.

b. Visually inspected after cleaning and heat treatment.

c. Tested 100 percent by magnetic particle or liquid penetrant testing method.

d. Tested 100 percent by radiographic or ultrasonic testing method.

e. Coupons shall be tested unless casting is defective.

F. Corrections of Defects for Carbon Steel, Bronze and Stainless Steel Castings:

1. The Equipment Supplier shall notify the Engineer at least 10 days in advance of repairs. Working drawings shall include defects in casting showing location, depth, and length of each defect. Repairs to castings shall be by welding using an approved welding procedure.

2. If five or more major defects are found in casting, the casting will be rejected and shall not be incorporated into the work.

3. Upon approval, repairs to castings shall be by an approved repair procedure and shall include the following:

a. Defective areas shall be excavated, cleaned, and ground to sound, clean metal.

b. Excavated areas shall be visually inspected and tested by magnetic particle or liquid penetrant testing methods.

c. Major Defects – A defect will be considered major when excavation exceeds 20 percent of wall thickness or 1 inch, whichever is smaller; or when the extent of excavation exceeds 10 square inches of casting surface. Major defects shall be charted and recorded.

d. Minor Defects – Defects requiring lesser excavation than as specified for a major defect shall be considered as minor defects.

e. Major Repairs – Prior to final heat treatment, repairs of major defects shall be tested by radiographic testing method. Where radiographic testing of repairs is not practical as determined by the Engineer, testing by ultrasonic method shall be used as approved. Major repaired areas shall again be tested by radiographic testing method after final heat treatment.

f. Minor Repairs – Prior to final heat treatment, repairs of minor defects shall be tested by magnetic particle or liquid penetrant method as approved.

g. Castings shall be visually inspected after repair work and final heat treatment.

h. Heat treated coupons shall be tested.

G. Inspection after Machining of Castings:

1. Machined surfaces of castings shall be inspected by magnetic particle or liquid penetrant testing method after rough machining.

2. Machined surfaces of castings shall be inspected by liquid penetrant testing method after final machining.

H. Surface Roughness of Castings:

1. Surface roughness of unmachined cast surfaces shall be equal to or better than as specified in ASTM A 802, Acceptance Level I.

2.04 STEEL FORGING

A. The Equipment Supplier shall provide documents for each type of forging to include forging process; working drawings; and inspection, test, and repair procedures, and test reports as specified prior to final acceptance of the forging.

B. Net dimensions of forging shall be shown on the working drawings.

C. Surface roughness of forging shall not exceed 250 microinches.

D. Forging shall be tested 100 percent by ultrasonic testing method after final heat treatment.

E. Defects in forging shall be removed by chipping or grinding with resultant depression flared into surrounding surface. Complete removal of defects shall be verified by approved nondestructive testing techniques. Sufficient base metal shall remain, as determined by the Engineer, to allow for subsequent repair. Repairs to forging shall be by welding using an approved welding procedure.

F. The Engineer shall be notified a minimum of 10 days in advance of repairs. Repairs to forging shall be tested 100 percent by ultrasonic testing method.

G. Forging shall be tested 100 percent by magnetic particle or liquid penetrant testing method after final machining.

2.05 CORROSION RESISTANT PROPERTIES OF STAINLESS STEEL

A. The Equipment Supplier shall take the following steps to preserve original corrosion resistant properties of stainless steel:

1. Descaling and cleaning shall conform to ASTM A 380, Subarticles 5 and 6.

2. Passivation shall conform to ASTM A 380, Subarticle 6.4.

3. Inspection of stainless steel after passivation shall conform to ASTM A 380, Subarticle 7.2.5.1.

4. Surface contaminants such as oxide scale, rust, grease, oil, chemical films, soil particles, weld spatter, metal chips, fluxes, dirt, sand or other nonvolatile deposits shall be removed prior to passivation process.

5. Fabrication of stainless steel components shall be performed in a work area away from areas where work on carbon steel is in process.

6. Carbon steel shall not be used to support stainless steel.

7. Stainless steel shall be shielded from carbon steel welding, cutting, grinding, and spatter.

8. Molds used in fabrication of stainless steel equipment shall be free of contamination.

9. Finishing on stainless steel shall be accomplished in such an environment and using procedures, which shall prevent contamination of stainless steel with carbon steel particles.

10. Carbon steel cutting tools shall not be used on stainless steel. Tools used on stainless steel shall be new, or tools used previously, exclusively for stainless steel machining or cleaning operations.

11. Mechanical cleaning of stainless steel shall be limited to:

    a. Using stainless steel wire brushes, aluminum oxide or silicon carbide grinding wheels; or

    b. Blasting with clean glass beads or walnut shells.

12. Cleaning solvents for stainless steel shall be acetone or alcohol.

13. Stainless steel items shall be protected from damage and contamination during handling, shipping and crating of equipment. Carbon steel slings, straps, chains, or other carbon steel items shall not be in contact with the stainless steel items.

14. Where crating is not practical, alternative methods of protection shall be used as approved.

2.06 WELDS AND WELDING

A. Welding shall be by shielded metal arc (SMAW), gas metal arc (GMAW), gas shielded flux cored arc (FCAW-G), gas tungsten arc (GTAW), submerged arc (SAW) or self-shielded flux cored arc (FCAW-S) welding process in accordance with the following codes and as specified herein:

1. Welding on pressure vessels requiring an ASME code stamp shall conform to ASME, Boiler and Pressure Vessel Code, Section VIII, Division 1.

2. Aluminum metalwork shall conform to AWS D1.2.

3. Stainless steel metalwork shall conform to AWS D1.6.

4. Sheet steel welding shall conform to AWS D1.3.

5. Carbon steel and other welding shall conform to AWS D1.1.

6. Welding of reinforcing steel shall conform to AWS D1.4.

7. Welding terms, symbols and definitions shall conform to AWS A2.4 and AWS A3.0.

8. Weld procedures and welding shall comply with limitations of welding variables listed in AWS codes, and testing requirements as specified.

9. Chemical analysis of weld metal shall be included with welding procedure qualification test data for stainless steel welds. Austenitic stainless steel procedure qualification analysis of weld metal shall include ferrite number.

10. Welding procedures using self-shielded flux cored arc (FCAW-S) welding process may be approved provided that each heat of welding electrodes used in the work meets a Charpy V-Notch Impact Test value of 20 foot-pounds at 0 degrees F, or material test requirements, whichever has the lowest test temperature. Tests shall be performed on test specimens taken from weld metal and heat affected zone of test plate.

11. Impact test procedures and methods shall be as specified for the material. When material specifications require impact tests, such impact tests shall be performed on test specimens taken from the weld material and heat affected zone of the test plate.

12. Use of multiple welding processes in the same weld joint shall require procedure qualification listing depth, location, and sequence of weld deposits for each process used on WPS sheet.

13. When material is to be heat treated, test plates shall be heat treated after welding in the same manner as the material.

B. Electrodes:

1. Electrodes for shielded metal arc welding of carbon steel shall be low hydrogen and shall conform to AWS A5.1 or AWS A5.5.

2. Electrodes for welded stainless steel overlay or welding stainless steel to carbon steel shall conform to AWS A5.4, AWS A5.9, or AWS A5.22 and shall be Type 309L or 309CB.

3. Electrodes and fluxes shall be maintained clean and free from moisture conforming to AWS D1.1, Section 7.3. Drying and holding ovens shall be equipped with temperature controls.

4. Electrodes for stainless steel welding and aluminum welding shall be as approved.

C. Welding Procedure, Welder and Welding Operator Qualification:

1. The Equipment Supplier shall notify the Engineer, in writing, prior to welding qualification test plates. Number of days of advance notice shall be as agreed upon by the Equipment Supplier and the Engineer.

2. Welding Procedure Specification (WPS) shall be used to qualify the welding procedure. WPS and Welding Procedure Qualification Record (WPQR) test results shall be approved prior to welding.

3. Welding procedures, welders and welding operators shall be qualified in presence of the Engineer unless otherwise approved. The Engineer may accept, upon the Equipment Supplier's written request, part or parts of the following:

   a. Previous welding procedures and welder or welding operator qualifications.

   b. Copies of certified test results of previous welding procedures witnessed by approved testing bureau or commercial testing laboratory, only if, representatives of the testing laboratory had witnessed welding of test plates and have accurately documented welding variables, witness, and witness title.

   c. Use of an approved testing bureau or commercial testing laboratory to witness qualification of welding procedures, welder, or welding operators.

4. Welding procedures, welder, or welding operator qualifications that include welding passes down slope greater than 15 degrees from horizontal will not be acceptable.

5. AWS prequalified welding procedures may be accepted for shielded metal arc welding (SMAW) process on carbon steel material group 1 and group 2 only, unless Charpy V-Notch Impact Testing is specified for the material.

6. Radiographic examination of welder or welding operator qualification test specimen will not be accepted. Welder's qualification in 6G position will not be accepted.

7. Welders and welding operators shall be qualified with the largest diameter electrode or wire to be used in the work.

8. Welders and welding operators for fillet welds shall be qualified by fillet weld break test.

D. Workmanship and Quality Requirements for Welds and Welding:

1. Welds shall be tested as specified in Paragraph 2.10, General Testing Requirements.

2. Welds shall be continuous and uniform through its entire length. Crown reinforcement shall not exceed 3/32-inch.

3. Welds shall blend smoothly and gradually into surfaces of base metal without undercutting or overlapping.

4. Welds in butt joints in water flow areas shall be ground flush with maximum reinforcement 1/16-in.

5. Fillet welds shall not be 1/16-inch larger or 1/32-inch smaller than the specified size.

6. Material misalignment shall not exceed 10 percent of thickness of thinner part being joined, but in no case exceed 1/8-inch.

7. Surfaces within 1-inch of any weld joint shall be free from scale, rust, paint, or other foreign substance before welding.

8. Temporary welded connections shall have weld metal removed flush with adjacent base metal. Removal of alignment or assembly devices by hammer blows will not be allowed. Nondestructive testing of temporary welded connections shall be as directed at no additional expense to the District.

9. Arc strikes are allowed in weld joints only. Arc strikes outside of the weld joint shall be ground smooth and Magnetic Particle tested and inspected in the presence of the Engineer.

10. Weld slag and splatter shall be removed prior to final inspection and coating. Needle scalers shall not be used to remove weld slag or splatter.

11. Welding shall be upward on sloped surfaces greater than 15 degrees from horizontal unless otherwise approved.

12. Welded joints to be coated or galvanized shall be boxed and sealed by welding.

13. Edges and corners of metal surfaces to receive coating shall be rounded to a radius of 1/16 inch.

14. Welding shall not be performed at an ambient temperature of 20 degrees F or below.

15. Butt joints on piping, or structural tubing, welded from one side without backing material shall not be considered a complete penetration weld until proven by examination by either radiographic or ultrasonic testing method.

16. Control of distortion and shrinkage shall conform to AWS D1.1, Section 7.2.

17. No welding shall be done unprotected in inclement weather such as rain, wind, or snow. No gas shielded welding process shall be performed when wind velocity makes shielding ineffective.

18. Metalwork shall not be welded after coating, unless coatings can be inspected and repaired, as determined by the Engineer.

E. Preheating:

1. Preheat shall not be above 400 degrees F prior to welding.

F. Stress Relief Heat Treatment:

1. Weldments that are machined, and weldments that retain pressure shall be stress relieved by heat treating unless otherwise approved.

2. Stress relief heat treatment shall be performed prior to final machining.

3. Weldments to be stress relieved by heat treating shall be shown on fabrication and machining working drawings.

4. Post weld heat treatment of stainless steel weldments shall be heat treated the same as the base material, and shall provide the corrosion resistance and physical properties of the base material.

5. No post weld heat treatment shall be performed on Grade CF10SMnN (Nitronic 60) material and weldments.

G. Air Testing:

1. Inaccessible compartments created by welding of stiffener plates, butt strap joints, reinforcing collars, slip-on flange connections or any other welded connections with overlapping steel shall be air tested.

2. After completion of welding, welded joints shall be air tested as follows:

   a. Two holes shall be drilled and tapped, either 180 degrees apart on pipe or at ends of each point. One hole shall be used for application of pressure and other hole shall be used for verification.

   b. Welded joint shall be swabbed with a concentrated soap solution, or other approved leak test fluid, and pressurized air of at least 30 psi shall be forced through connections as directed.

   c. Defective welds indicated by formation of bubbles at leaks shall be repaired and retested.

   d. Fittings required for air testing shall be removed and holes shall be sealed by plug welding.

   e. Plug welding area shall be magnetic particle tested after weld has air cooled to ambient temperature.

2.07 NONDESTRUCTIVE TESTING

A. General:

1. Unless otherwise directed or approved, final nondestructive testing shall be performed after completion of welding operations, machining, grinding, heat treatment, and hydrostatic pressure testing.

2. The Equipment Supplier shall notify the Engineer of the proposed time for each nondestructive testing. Number of days of advance notice shall be as agreed upon by the Equipment Supplier and the Engineer.

3. Selected method of nondestructive testing shall provide satisfactory interpretable results in accordance with applicable nondestructive code requirements.

4. Location of tests on welds not requiring 100 percent testing shall be as determined by the Engineer.

5. If any welded portion tested fails to meet acceptance standards, then welding of the same process shall be 100 percent tested until such time the testing indicates that the cause of rejections has been corrected.

6. If the Engineer determines the specified method of nondestructive testing cannot be used under conditions encountered in the work, an alternate method of testing shall be used at no additional expense to the District. Ultrasonic, radiographic and radioscopic testing methods will be

designated as alternates. Liquid penetrant and magnetic particle testing methods will be designated as alternates.

7. Nondestructive testing technicians and operators shall be NDT Level II as defined in ASNT Recommended Practice No. SNT-TC-1A. Level II technician shall sign the test reports.

8. Nondestructive test report shall include a sketch or weld map, which clearly identifies physical outline of the work and areas of inspection.

B. Radiographic Testing:

1. General:

   a. Radiographs shall conform to ASTM E 94, and as specified.

   b. Radiographic film shall be developed and interpreted by NDT Level II technician.

2. Welds:

   a. Radiographic testing procedures and standards for welds shall conform to AWS D1.1 and AWS D1.2 applicable codes in conjunction with the limitations specified.

3. Quality of Radiographs:

   a. Radiographs shall be free of blemishes, which interfere with interpretation. Sharp protrusions made by film clips shall be removed.

   b. Image quality indicators (penetrameters) shall be hole-type and selected and placed conforming to ASTM E 94 to assure that minimum radiography quality level 2-2T is obtained.

   c. Penetrameter shall be placed on radiation source side of the test object. Penetrameter markings and 2T hole shall show on the radiograph. Penetrameter placement on film side of the test object shall be as approved. The penetrameter shall be placed at a minimum of every 90 degrees when making panoramic radiographs.

   d. A technique shot shall be made to demonstrate ability to produce an acceptable radiograph. The technique shot shall conform to ASTM E 94.

   e. Film density shall be between 2.5 and 3.5 except that density shall not vary more than 0.50 as measured on a densitometer. Radiographs having densities of less than 2.5 or more than 3.5 will be considered defective work and will be rejected.

4. Radiographic Film and Screens:

a. Radiographic film shall conform to ASTM E 94, Type 1 for material thickness less than 1 inch and Type 2 for material thickness 1 inch and over.

b. Lead foil screens shall be used.

c. Minimum film size shall be 4-1/2 inch by 17 inch unless otherwise approved.

5. Match Marking:

a. Film shall be marked with date, specification number, contract number, piece, or section number and weldment number. Tested areas and film shall be marked to enable physical matching of radiograph and metal.

6. Film Placement:

a. Film shall cover a minimum of 1/2 inch of base metal adjacent to area of testing. The area shall be free from obstructions except for the penetrameters.

7. Source Distance:

a. Minimum source-to-film distance shall be 36 inches for X-Radiography and 20 inches for Gamma-Radiography plus thickness of the test object. If it is physically impossible to provide the specified distances, maximum distance possible shall be used.

8. Acceptance Standards for Steel Castings:

a. Acceptance radiographic standards for steel castings shall conform to the following:

Finished Thickness Dimension	ASTM	Discontinuity Category	Severity Level
Less than 2 inches	E 446	A. Gas and blowholes	3
		B. Sand spots and inclusions	3
		C. Internal shrinkage	2
		D. Hot tears	Unacceptable
		E. Cracks	Unacceptable
		F. Unfused Chaplets	1
		G. Internal chills	Unacceptable

Finished Thickness Dimension	(Cont'd) ASTM	Discontinuity Category	Severity Level
2 inches to 4-1/2 inches	E 186	A. Gas porosity	3
		B. Inclusions	4
		C. Shrink-Type 1	4
		Shrink-Type 2	4
		Shrink-Type 3	3
		D. Linear Discontinuities	Unacceptable
		E. Chaplets-Type 1	3
		Chaplets-Type 2	1

9. Unacceptable chaplets shall be excavated to a minimum depth of 1 inch from each side as approved.

10. Preparation of Welds:

    a. Welds that are not required to be grounded flush shall be grounded to remove any surface irregularities that would obscure objectionable weld discontinuities in the radiograph.

    b. Flush welds shall be grounded smooth and flush with surface of base metal.

11. Acceptance Standards for Welds:

    a. Acceptance standards for welded joints examined by radiographic testing method shall conform to AWS D1.1, Section 8.12.2, Figure 8.2 for cyclically loaded tension stress connections.

C. Ultrasonic Testing:

1. General:

    a. Ultrasonic testing shall conform to ASTM E 114 and E 587 for material, and conform to AWS D1.1, Section 8, Part C for welds unless otherwise approved.

    b. Ultrasonic angle beam testing shall be limited to 1/2 inch and thicker material.

    c. Evaluation transducer shall have 1-1/8 inch diameter and frequency of 2.25 MHz. Other transducer sizes or frequencies may be used to determine orientation or to define specific discontinuities detected during overall scanning. If a 2.25 MHz frequency does not provide adequate penetration, the next lower frequency that will provide adequate penetration shall be used as approved.

d. A commercial liquid couplant shall be used between transducer and test surface, and shall have the same characteristics as liquid couplants used for calibration of the instruments.

e. Surface roughness of test surface shall not exceed 250 microinches.

f. Ultrasonic testing shall be performed on material using a distance amplitude curve for discontinuity evaluation. Evaluation reference standard shall contain bore reflectors as required to determine degree of discontinuities. Size and depth of flat bottom bored hole reflectors shall be as approved.

g. Reference standard shall be fabricated from a material that has the same attenuation characteristics, plus or minus 5 percent, as the material being tested.

h. Ultrasonic test report shall include test frequencies, method of setting sensitivity, type of instrument, record of surface finish, type of couplant, description and dimensions of calibration standard, type and diameter of transducers employed, technician's signature and date of test. A sketch showing physical outline including dimensions and areas not tested due to geometric configuration, and distribution of ultrasonic indications shall be included in the report.

i. Working drawings for forging and casting shall include information covering sizes and depths of reflectors for evaluation reference standard for that particular material and area to be tested.

j. Scanning sped shall not exceed 6 inches per second.

k. Calibration shall be performed every four hours, every time machine is turned on, and every time operator is changed.

l. Recorded indications shall be reported to the Engineer prior to end of each day.

2. Steel Castings:

a. Ultrasonic testing of steel castings shall conform to ASTM A 609. Acceptance standards shall conform to ASTM A 609, quality level 2.

3. Steel Forging:

a. Ultrasonic testing of steel forging shall conform to ASTM A 388 and the following:

1) Transducer frequency shall be 2.25 MHz.

2) Transducer diameter shall be 1-1/8 inch for longitudinal wave and 1 inch by 1/2 inch for shear wave.

3) Sensitivity reference standard shall be 1/8 inch diameter hole bored through a 1-1/4 inch by 4 inch by 2 inch piece taken from a material with the same chemical and mechanical properties. Hole shall be perpendicular to 2 inch by 4 inch surfaces of the block. If surface to be tested is curved, the test block surface shall have the same radius. Sensitivity reference standard shall have the same heat treatment as the material to be tested and shall be used for both shear wave and longitudinal wave testing.

4) Reference amplitude of reflection shall be equivalent to a 1/8 inch side drilled hole at 1 inch of metal path.

5) Scanning shall be accomplished at 1.5 times evaluation sensitivity.

6) For either longitudinal or shear wave testing, signal from the specified standard shall be placed at 80 percent full screen deflection.

7) Compensation for attenuation due to transverse metal path shall be as approved.

b. Evaluation criteria shall be as follows:

1) Indications, which exceed 20 percent full screen deflection, shall be recorded.

2) Indications, which exceed 80 percent full screen deflection, shall be cause for rejection of section of material in which the indications are contained.

3) Recordable indications which exceed 20 percent and are less than 80 percent full screen deflection with length of 1 inch or greater and are within 2 inches of center shall be cause for rejection.

4) Recordable indications which exceed 20 percent and are less than 80 percent full screen reflection with a length of 1/2 inch or greater and lie within 3 inches of another indication shall be cause for rejection.

5) Recordable indications which exceed 20 percent and are less than 80 percent full screen deflection and show indications of cracking shall be cause for rejection.

6) Final evaluation of any recordable indication shall be as approved.

4. Acceptance Standards for Welds:

    a. Acceptance standards for welded joints examined by ultrasonic testing method shall conform to AWS D1.1, Section 8.13.2, Table 8.3 including notes for cyclically loaded connections.

    b. Ultrasonic testing shear wave inspection shall cover weld deposits and heat affected zones.

    c. Longitudinal waves shall cover heat affected zones.

D. Magnetic Particle Testing:

1. General:

    a. Dry powder magnetic particle testing shall conform to ASTM E 709, unless otherwise specified.

    b. Surfaces to be inspected by magnetic particle testing methods shall be clean and free of contaminants such as oil, grease, loose rust, scale, paint, weld flux and weld splatter. Surfaces shall be prepared for testing by grinding the areas smooth to allow clear and accurate interpretation of results.

2. Acceptance Standards for Castings:

    a. Acceptance standards for magnetic particle testing of castings shall conform to ASTM E 125 and as follows:

Type	Discontinuity	Degree
I	Linear Discontinuities (hot tears and cracks)	1
II	Shrinkage	1
III	Inclusions	1
IV	Internal chills and unfused chaplets	1
V	Porosity	1

    b. Linearly disposed discontinuities shall be evaluated on the same basis as Type I discontinuities.

3. Acceptance Standard for Forging:

    a. Any of the following defects found during magnetic particle testing of forging will not be accepted:

        1) Crack or lap (linear defects).

        2) Single indication exceeding 3/8 inch in length.

3) Linearly disposed indications, which exceed 3/8 inch in length and are separated by less than 3/8 inch from other unacceptable indications.

4) Length of 1-1/4 inch of disconnected indications separated by no more than 1/8 inch.

4. Acceptance Standards for Welds:

a. Acceptance standards for welds examined by magnetic particle testing shall conform to AWS D1.1, Section 6 for cyclically loaded tension stress connections. Welds will be rejected for any of the following:

1) Linear indication.

2) Crack.

E. Liquid Penetrant Testing:

1. Liquid penetrant testing shall conform to ASME Section V, Article 6 and as follows:

a. Surfaces shall be tested after final machining.

b. Abrasive blasted surfaces are not acceptable for liquid penetrant testing.

c. Temperature of penetrant materials and surface of part to be tested shall be between 50 degrees F and 100 degrees F. Where it is not practical to comply with temperature limitations, test procedure shall be qualified to the intended temperature conforming to ASTM E 165, Article 9.2.

d. Test area shall be kept covered with liquid penetrant for time recommended by the penetrant manufacturer.

e. Evaluation of indication shall be made within a minimum of 7 minutes and a maximum of 30 minutes.

2. Acceptance Standards:

a. Definitions:

1) Linear indication is defined as an indication where length is more than twice the width.

2) Round indication is defined as an indication where length is not more than twice the width.

3) Pinpoint porosity indication is defined as an indication, which does not exceed 1/32 inch in diameter.

4) Linear disposition is defined as location of four or more pinpoint porosity indications in a line no more than 3/8 inch long.

b. Welded Joints:

1) Welded joints shall be free of cracks or other linear indications.

2) For any 6 inches of weld length there shall be:

a) No rounded indications exceeding 1/8 inch maximum dimension, nor total indication length exceeding 5/16 inch, excluding pinpoint porosity.

b) No linearly disposed pinpoint porosity indication.

c. Other surfaces:

1) Unless otherwise specified, other surfaces shall include:

a) No crack or linear indication.

b) No more than three rounded indications (maximum dimension of any one indication 3/32 inch) in a line separated by 1/16 inch (edge to edge) or less.

F. Bubble Emission Testing:

1. Bubble emission testing shall conform to ASTM E 515, Liquid Application and as directed.

2.08 GALVANIZING

A. Galvanizing of rolled, pressed, or forged steel shapes, plates, bars and weldments shall conform to ASTM A 123.

B. Galvanizing of bolts, nuts, washers and hardware shall conform to ASTM A 153.

C. Galvanizing shall be performed after fabrication.

D. Welds shall be abrasive blasted clean prior to galvanizing.

E. Edges shall be rounded to a minimum of 1/16 inch radius.

F. Metalwork shall not be heated or welded after galvanizing unless approved.

G. Upon approval by the Engineer, the Equipment Supplier may repair minor galvanizing defects provided the repairs conform to ASTM A 780.

2.09 ASSEMBLY OF METALWORK

A. Metalwork shall be factory assembled whenever practical.

B. Each assembly shall be checked to ensure that clearances have been provided and that binding does not occur in any moving or removable parts.

C. Parts shall be thoroughly cleaned of packing compounds, dirt, dust, grit or other foreign matter prior to assembly.

D. Burrs, rough and sharp edges and other flaws shall be removed prior to assembly.

E. Tools, which would damage surface of rods, bolt heads, nuts, and other parts, will not be allowed.

F. Screws shall be tightened uniformly and firmly without overstressing threads.

G. Bolt Tightening:

   1. Slip critical connections shall use direct tension indicator bolts, and shall be tightened with a specifically configured wrench until the splined end shears off.

H. High strength bolts shall be installed by turn-of-nut method.

I. High strength bolts and anchor bolts shall be lubricated with graphite and oil compound lubricant before assembly.

J. Stainless steel threads shall be lubricated with approved lubricant, prior to assembly.

K. Bolt holes shall be aligned using approved tapered devices. Bolts shall not be used as alignment devices.

2.10 GENERAL TESTING REQUIREMENTS

A. Workmanship and nondestructive testing requirements specified shall be incorporated into each and every phase of the work unless specifically waived in the related sections.

B. Methods of nondestructive testing to be used on various portions of the work including casting and forging shall be in accordance with the following schedule unless specifically waived in the related sections:

C. The methods of nondestructive testing to be used for castings and forgings are detailed in the applicable articles of this section.

NONDESTRUCTIVE TEST SCHEDULE

Item	Type of Weld	Test Method
Shop Welds	Complete Joint Penetration < 1/2 inch	100% Radiographic or 100% Ultrasonic
	Complete Joint Penetration ≥ 1/2 inch	100% Radiographic or 100% Ultrasonic
	Partial Joint Penetration	25% Magnetic Particle
	Fillets < 5/16 inch material	Visual Only
	Fillets ≥ 5/16 inch material	25% Magnetic Particle
Field Welds	Complete Joint Penetration	100% Radiographic
	Partial Joint Penetration	25% Magnetic Particle
	Fillets	25% Magnetic Particle

PART 3 EXECUTION

Not Used

PART 4 PAYMENT

4.01 PAYMENT

A. The contract prices shall include full compensation for all costs incurred under this section.

END OF SECTION

SECTION 09900
PAINTS AND COATINGS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section covers requirements for materials and application of painting and coating systems.

B. Related work specified elsewhere:

1. All specification sections in which painting and/or coating is specified.

1.02 SUBMITTALS

A. General: Make submittals in accordance with Section 01300.

B. Product Data

1. Product Manufacturer's data sheets shall show the following information:
    a. Percent solids by volume.
    b. Minimum and maximum recommended dry-film thickness per coat for prime, intermediate, and finish coats.
    c. Recommended surface preparation.
    d. Recommended thinners.
    e. Statement verifying that the specified prime coat is recommended by the Manufacturer for use with the specified intermediate and finish coats.
    f. Application instructions including recommended equipment and temperature limitations.
    g. Curing requirements and instructions.

1.03 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

A159.1 Surface Preparation Specifications

B. American Society for Testing and Materials (ASTM)

D2697 Test Method for Volume Non-Volatile Matter in Clear or Pigmented Coatings

C. American Water Works Association (AWWA)

C105 Polyethylene Encasement for Ductile Iron Pipe Systems

D. National Sanitation Foundation (NSF)

NSF-61 Drinking Water System Components Health Effects

PART 2 - PRODUCTS

2.01 MATERIALS

A. Coating Materials:

1. Material Time Limits: Materials shall be used within the time limit as recommended by the manufacturer.

Manufacturer's Recommendations: Copies of the manufacturer's recommendations for mixing and applying materials shall be furnished to the Engineer prior to mixing or applying the materials.

2. Manufacturer's Standards: Comply with manufacturer's recommendations and standards unless otherwise specified.

The top coat and any intermediate coat shall be a product of the manufacturer of the prime coat.

3. Coating materials shall conform to the following:

Material	Specification or Manufacturer
Alternative Finish	The manufacturer's standard coating materials and procedures may be submitted for consideration, provided the materials and procedures are equivalent or greater than what is specified and that such coating has been properly applied, and is compatible with subsequent coatings. Surface preparation, coatings, coating manufacturer's data sheet, dry film thickness, application procedures, and inspection techniques shall be submitted to the Engineer at least 30 days prior to coating
Corrosion Preventive Compound	Military Specifications MIL-C-16173E Grade 4. Chemsol Co., Mil-C-16173E Grade 4; Valvoline, TECTYL 846; or equal.
Fusion Bonded Epoxy	ANSI/AWWA C550. Epoxy resin shall be one hundred percent dry powder type epoxy resin conforming to Minnesota Mining and Manufacturing Co., Scotchkote No. 134 or Scotchkote No. 206N; Morton International, Corvel ECA-1626; or equal.
High Build Aliphatic Urethane	Carboline 133 HB; Devoe Devthane 359; or equal. Hi-build aliphatic urethane shall be a product of the manufacturer of the aluminum epoxy mastic.

Material	Specification or Manufacturer
High Solids Epoxy NSF Approved to Standard 61	Carboline/KopCoat, Super HiGard 891; Ameron Protective Coating Div., Amercoat 395; Devoe Coating Co., BarRust 233; or equal.
Reinforced Epoxy	Chesterton, ARC S2; Carboline, Plasite 4550S; or equal.
Fast Cure Epoxy Mastic	Macropoxy 646 PW epoxy by Sherwin Williams or equal.

B. Abrasive Blast Material:

1. Abrasive blast material shall be dry, clean angular material as recommended by the coating manufacturer. The blast material shall be new and shall not be reused or recycled.

Contractor may propose alternative materials, only to be used upon approval by the Engineer.

PART 3 - EXECUTION

3.01 COATING SCHEDULE

A. Method of surface preparation, type of coating, number of coats, dry film thickness, time of application and colors shall conform to the schedule below:

B. COATING SCHEDULE

Item	Method of Surface Preparation	Coating	No. of Coats and Mils Dry Film Thickness	Time of Application
Exterior ferrous surfaces exposed to the atmosphere Interior and exterior ferrous surfaces located indoors	SP 5 or 2.0-3.0 mil profile depth	High build modified aluminum Epoxy Mastic High Build Aliphatic Urethane Top Coat or approved alternative finish	2 coats 1st coat 4.0-5.0 mils 2nd coat 3.0-4.0 mils Total 7.0-9.0 mils	Shop applied

Interior an exterior of ferrous surfaces exposed to moisture: Turbine, carbon steel pipe sections, and valve parts	SP 5 3.0 mils Profile depth.	High Solids Epoxy	3 coats 1st coat 6.0 max. 2nd coat 6.0 max. 3rd coat as Required Total: 16.0 min.	Shop applied
Machined or finished ferrous surfaces exposed during shipment.	SP 1	Corrosion preventive compound	According to product application instructions.	Prior to shipment

3.02 WEATHER CONDITIONS

A. Do not paint in the rain, wind, snow, mist, and fog or when steel or metal surface temperatures are less than five degrees Fahrenheit above the dew point.

B. Do not apply paint when the relative humidity is above 85 percent or the temperature is above 90 degrees Fahrenheit.

C. Do not paint when temperature of metal to be painted is above 120 degrees Fahrenheit.

D. Do not apply alkyd or inorganic zinc paints if air or surface temperature is below 40 degrees Fahrenheit or expected to be below 40 degrees Fahrenheit within 24 hours.

E. Do not apply epoxy and polyurethane paints on an exterior or interior surface if air or surface temperature is below 60 degrees Fahrenheit or expected to drop below 60 degrees Fahrenheit in 24 hours.

3.03 SURFACE PREPARATION

A. Do not sandblast or prepare more surface area in one day than can be coated in one day; prepare surfaces and apply coatings the same day. Remove all sharp edges, burrs, and weld spatter. Do not sandblast PVC, CPVC, or FRP piping or equipment. Do not sandblast epoxy- or enamel-coated pipe that has already been factory coated, except to repair scratched or damaged coatings.

B. Surface preparation shall conform with the SSPC (Steel Structure Painting Council, Surface Preparation Specifications, ANSI A159.1) specifications as follows:

1. Solvent Cleaning SP-1
2. Hand Tool Cleaning SP-2
3. Power Tool Cleaning SP-3
4. White Metal Blast Cleaning SP-5
5. Commercial Blast Cleaning SP-6

6. Brush-Off Blast Cleaning SP-7
7. Near-White Blast Cleaning SP-10

C. Wherever the words "solvent cleaning," "hand tool cleaning," "wire brushing," "blast cleaning," or similar words are used in these specifications or in paint Manufacturer's specifications, understand they refer to the applicable SSPC specifications listed above.

D. Dust blasting is defined as cleaning the surface through the use of very fine abrasives, such as siliceous or mineral abrasives, 80-mesh to 100-mesh. Apply a fine etch to the metal surface to clean the surface of any contamination or oxide.

E. Remove oil and grease from metal surfaces in accordance with SSPC SP-1. Use clean cloths and cleaning solvents and wipe dry with clean cloths. Do not leave a film or greasy residue on the cleaned surfaces before sandblasting.

F. Remove weld spatter and weld slag from metal surfaces and grind smoothly rough welds, beads, peaked corners, and sharp edges including erection lugs in accordance with SSPC SP-2 and SSPC SP-3.

G. Neutralize welds with a chemical solvent that is compatible with the specified coating materials. Use clean cloths and chemical solvent. Wipe dry with clean cloths. Do not leave a residue on the cleaned surfaces.

3.04 FIELD TOUCH-UP OF SHOP-APPLIED PRIME COATS

A. Remove oil and grease surface contaminants on metal surfaces in accordance with SSPC SP-1. Use clean rags wetted with a degreasing solution, rinse with clean water, and wipe dry.

B. Remove dust, dirt, salts, moisture, chalking primers, or other surface contaminants that will affect the adhesion or durability of the coating system. Use a high-pressure water blaster or scrub surfaces with a broom or brush wetted with a solution of trisodium phosphate, detergent, and water. Before applying intermediate or finish coats to inorganic zinc primers, remove any soluble zinc salts that have formed by means of scrubbing with a stiff bristle brush. Rinse scrubbed surfaces with clean water. Wash water needs to be contained and properly disposed of.

C. Remove loose or peeling primer and other surface contaminants not easily removed by the previous cleaning methods in accordance with SSPC SP-7. Take care that remaining primers are not damaged by the blast cleaning operation. Remaining primers shall be firmly bonded to the steel surfaces with blast cleaned edges feathered.

D. Remove rust, scaling, or primer damaged by welding or during shipment, storage, and erection in accordance with SSPC SP-10. Take care that remaining primers are not damaged by the blast cleaning operation. Remaining primers shall be firmly bonded to the steel surfaces with blast cleaned edges feathered.

E. Use repair procedures on damaged primer which protects adjacent primer. Blast cleaning shall require the use of lower air pressure, smaller nozzles, and abrasive particle sizes, short blast nozzle distance from surface, shielding, and/or masking.

F. Remove dust, blast particles, and other debris after abrasive blast cleaning of damaged and defective areas by dusting, sweeping, and vacuuming; then apply the specified touch-up coating.

G. Field touch-up surfaces that are shop primed with inorganic zinc primers with organic zinc primer to cover all scratches or abraded areas.

H. Field touch-up other surfaces that are shop primed with the same primer used in the original prime coat.

3.05 PAINTING SYSTEMS

A. Provide materials for a specified painting system, including primer, intermediate, and finish coats by the same manufacturer. Thinners, cleaners, driers, and other additives shall be as recommended by the paint manufacturer for the particular coating system.

B. Deliver paints to the jobsite in the original, unopened containers.

3.06 QUALITY CONTROL

A. Inspection Notification:

1. The Contractor shall notify the Engineer 5 days in advance of the start of any surface preparation work or coating application work. Such work shall be performed in the presence of the Engineer unless otherwise approved in writing.
2. Illumination and illumination supports shall be provided while work and inspection is in progress. Illumination shall be by an electrical lighting system equivalent to at least 100-foot-cnadles intensity on all surfaces to be inspected.

B. Surface Preparation Inspection Procedures:

1. Visual: Surface preparation shall conform to SSPC VIS 1 for the appropriate level of surface preparation as specified in the coating schedule.
2. Profile: Surface profile shall be sharp and angular, and shall conform to the specifications in the coating schedule. The abrasive cleaned surface will be measured in accordance with ASTM D 4417 Method B or Method C and SSPC PA-17. Method B apparatus shall be capable of saving and printing results of measurements which shall be submitted. Method C replica tape impressions shall be submitted.
3. Chloride Contamination: Surfaces to be coated shall be testing for the presence of chlorides on the surface to be coated immediately prior to coating. Testing shall conform to SSPC Technology Guide 15 Method A2. An acceptable test kit is the Chlor Test Kit, available from Chlor Rid International. Tests shall be performed adjacent to the weld areas, if present, otherwise, test sites shall be selected to be representative of the surface as a whole. The rate of testing shall be as follows:

a. Five tests for the first 1,000 square feet.
b. Two tests for each additional 1,000 square feet for the next 3,000 square feet.
c. One test for each additional 2,000 square feet.
d. One or more chloride measurements greater than 3 micrograms per square centimeter shall be cause for rejection. The supplier will then be required to removed soluble salts.

C. Coating Inspection Procedures:

1. Dry Film Thickness: Dry film thickness will be measured using Elcometer Instruments, Ltd.; DeFelsko Corporation, Positector; Minitest/Elecktro-Physik; or equal.
2. Holiday Detection: Holiday detection shall be performed over 100 percent of the coated surface. The holiday detection method shall be determined by the total film thickness specified. The voltage shall be maintained through the inspection. Test shall be conducted in accordance with ASTM D 5162.
   a. Coating systems with a dry film thickness of less than 20 mils shall be inspected for discontinuities and voids with a low voltage detector of the wet sponge type, Tinker and Rasor, Model MI; KD Bird Dog, Model KD Bird Dog Holiday Detector; Elcometer 270; or equal.
   b. Coatings with a dry film thickness of more than 20 mils shall be inspected for discontinuities and voids with a high voltage low current spark type detector, Tinker and Rasor, Model AP-W Series; Pipeline Inspection Co., Spy No. 700 and 900 Series Holiday Detector; Elcometer Model 236 DC; or equal. The minimum voltage of the detector shall be adjusted to 100 volts per mil of the average thickness of the coating to be inspected. The voltage shall be maintained throughout the inspection.
3. Adhesion: Test shall be conducted in accordance with ASTM D4541, Test Method D, using apparatus under Appendix D. Coating must meet a minimum value of 1,700 psi.

D. Test Equipment: The Contractor shall have calibrated equipment to meet the requirements of the specifications.

E. Test Equipment Use: The test equipment specified shall be made available for use by the Engineer in performing duplicate or additional coating inspections as deemed necessary by the Engineer.

F. Coating Log: For Daily Coating Inspection Reports, the Contractor should use the form that will be provided.

G. The Contractor shall arrange for the presence of the coating manufacturer’s technical representative on-site if quality control or application problems arise, or at the request of the Engineer.

3.07 REPAIR OF IMPROPERLY COATED SURFACES

A. If the item has an improper finish color or insufficient film thickness, clean and recoat the surface with the specified paint material to obtain the specified color and coverage. Sandblast or power-sand visible areas of chipped, peeled, or abraded paint, feathering the edges. Then prime and finish coat in accordance with the specifications. Work shall be free of runs, bridges, shiners, laps, or other imperfections.

END OF SECTION

SECTION 11050
OPERATION AND MAINTENANCE MANUAL

PART 1 – GENERAL

1.1 O&M MANUAL

A. The Equipment Supplier shall submit technical operation and maintenance information for each item of mechanical, electrical and instrumentation equipment, furnished under this contract, in an organized manner in the Technical Manual. It shall be written so that it can be used and understood by the Owner’s operation and maintenance staff.

B. The Technical Manual shall be subdivided first by specification section number; second, by equipment item; and last, by "Category." "Categories" shall conform to the following (as applicable):

1. Category 1 - Equipment Summary:
   a. Summary: A summary table shall indicate the equipment name, equipment number, and process area in which the equipment is installed.
   b. Form: The Engineer will supply an Equipment Summary Form for each item of mechanical, electrical and instrumentation equipment in the Work. The Equipment Supplier shall fill in the relevant information on the form and include it in Part 1.
2. Category 2 - Operational Procedures:
   a. Procedures: Manufacturer-recommended procedures for the following shall be included in Part 2:
      1) Installation
      2) Adjustment
      3) Startup
      4) Location of controls, special tools, equipment required, or related instrumentation needed for operation
      5) Operation procedures
      6) Load changes
      7) Calibration
      8) Shutdown
      9) Troubleshooting
      10) Disassembly
      11) Reassembly
      12) Realignment

13) Testing to determine performance efficiency

14) Tabulation of proper settings for all pressure relief valves, low and high pressure switches, and other protection devices

15) List of all electrical relay settings including alarm and contact settings

3. Category 3 - Preventive Maintenance Procedures:

   a. Procedures: Preventive maintenance procedures shall include all manufacturer-recommended procedures to be performed on a periodic basis, both by removing and replacing the equipment or component, and by leaving the equipment in place.

   b. Schedules: Recommended frequency of preventive maintenance procedures shall be included. Lubrication schedules, including lubricant SAE grade, type, and temperature ranges, shall be covered.

4. Category 4 - Parts List:

   a. Parts List: A complete parts list shall be furnished, including a generic description and manufacturer's identification number for each part. Addresses and telephone numbers of the nearest supplier and parts warehouse shall be included.

   b. Drawings: Cross-sectional or exploded view drawings shall accompany the parts list.

5. Category 5 - Wiring Diagrams: Part 5 shall include complete internal and connection wiring diagrams for electrical equipment items.

6. Category 6 - Shop Drawings: This part shall include approved shop or fabrication drawings, complete with dimensions.

7. Category 7 - Safety Procedures: This part describes the safety precautions to be taken when operating and maintaining the equipment or working near it.

8. Category 8 - Documentation: All equipment warranties, affidavits, and certifications required by the Technical Specifications shall be placed in this part.

9. Category 9 – Troubleshooting. This part shall include troubleshooting guides for each piece of equipment or system.

C. The Equipment Supplier shall furnish to the Engineer three (3) identical final version of Technical Manuals. Each set shall consist of one or more volumes, each of which shall be bound in a standard size, 3-ring, looseleaf, vinyl plastic hard cover binder suitable for bookshelf storage. Binder ring size shall not exceed 2.5 inches. A table of contents indicating all equipment in the manuals shall be prepared.

D. Manuals shall be submitted in final form to the Engineer as mutually agreed upon with Equipment Supplier and the Owner.

E. Three (3) sets of draft manuals shall be submitted 60 days prior to required manufacturer training, as indicated in Section 01730. Within 30 days of completion of training submit final copies of manuals as indicated above.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 11500
TURBINE SHUTOFF VALVE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements for one (1) new Turbine Shutoff Valve (TSV) and accessories.

B. Service Departments.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. American Society for Testing and Materials (ASTM)

ASTM A 181	Carbon Steel Forgings for General-Purpose Piping
ASTM A 182	Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A 193	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194	Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 216	Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A 234	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 312	Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 516	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 564	Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A 576	Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM B 505	Copper-Base Alloy Continuous Castings

ASTM B 584	Copper Alloy Sand Castings for General Applications
ASTM D 3951	Commercial Packaging

B. American Society For Testing And Materials (ASTM)

C. ASME International (ASME)

ASME B16.11	Forged Fittings, Socket-Welding and Threaded
ASME B31.1	Power Piping
ASME B40.1	Gauges - Pressure Indicating Dial Type - Elastic Element
ASME B&PV	Boiler and Pressure Vessel Code; Section VIII, Pressure VIII Div 1 Vessels Division 1 - Base Coverage

D. American Welding Society (AWS)

AWS D1.1 (2020) Structural Welding Code Steel

E. National Electrical Manufacturers Association (NEMA)

F. National Fire Protection Association (NFPA)

NAFP 70	National Electrical Code

G. National Fluid Power Association (NFLPA)

H. Society Of Automotive Departments (SAE)

I. Underwriters Laboratories (UL)

1.03 SUBMITTALS

A. Submit in accordance with Section 01300 – Submittals.

B. Ninety (90) days before proceeding with manufacture of the equipment or components, the Equipment Supplier shall submit general assembly drawings, subassembly drawings, detail drawings, calculations, engineering data, catalog sheets, and similar engineering documents required to demonstrate fully that all parts conform to the provisions and intent of this Section, and to the requirements related to installation, operation, and maintenance. Drawings shall show all necessary dimensions and fabrication details, including the type and grade of materials, details of welded and bolted joint connections, tolerances, clearances, surface finish, nondestructive examinations, and all field joints.

C. Shop Drawings shall include, but not limited to the following:

1. General arrangement drawing of combined turbine inlet valve assembly including servomotor, counterweight mechanism, penstock spools, bypass line and appurtenances, including all clearance dimensions to the surrounding structure and minimum clearance distances around equipment required to access equipment for service/ repair/removal
2. Cross sectional drawing of combined turbine inlet valve assembly and servomotor, showing the internal arrangement of parts, working clearances and other details.
3. Valve body, valve disc, valve spool pieces, dismantling joint, valve operating arms and counterweight, bypass valve, bypass line, and servomotor
4. Details of dogging device, servomotor mounting support and valve position indicator.
5. Fabrication and machining drawings with Bill of Materials.
6. Hydraulic and electrical schematics, including legends to identify all components.
7. Electrical wiring diagrams and interconnects for instrumentation and auxiliaries.
8. Lifting and handling diagram.
9. Other drawings specified herein or may be needed to clarify or document the design.
10. All drawings marked with equipment tag numbers shall be in accordance with a numbering system approved by the Owner

D. Engineering Data

1. Datasheets showing capacities, ratings, weights, and performance data.
2. Load diagrams showing static and dynamic loads transferred from the valve assembly to the supporting structures and connections.
3. Operating force (valve torque) calculations across full range of valve openings from fully closed to 100% open; seating and unseating force calculations; and safety of closure calculations.
4. Analysis of valve components that are project-specific and are not pre-engineered.
5. Seismic calculations (stamped and signed by a certified California structural engineer) or shake table test data certifying that the valve, servomotor and counterweight mechanism and appurtenances will be operable post-earthquake in accordance with ASCE 7-10, Section 13.
6. Head loss coefficient calculations for the valve from full closed through 100% opening, including supporting field or factory test data substantiating the loss coefficient. Scaled test results from a smaller valve (not smaller than 72 inches diameter) may be used for this requirement.

E. Procedures and Instructions

1. Manufacturing process plan (MPP).
2. Inspection and test plan (ITP) – for shop and field work.
3. Welding procedures specifications (WPS).

4. Post weld heat treatment and stress relief procedures.
5. Nondestructive examination (NDE) procedures and specifications.
6. Shop assembly and factory test procedures with checksheets.
7. Installation drawings, procedures and checksheets.
8. Field testing and commissioning procedures with checksheets.
9. Complete O&M manual (electronic and hardcopy) in accordance with Section 01300 – Submittals.
10. Other procedures or quality documents specified in Section 01400 – Quality Assurance or in this Section that are needed to clarify or document the work.

F. Reports

1. Factory test report.
2. Field test report.

G. Shipping and Delivery Plan including a shipping list which describes what is to be shipped, when it is to be shipped, what is to be shipped in each container or vehicle, protection details, mode of transportation, long term/ short term storage requirements, and contact information for transportation company.

1.04 RELATED WORK SPECIFIED ELSEWHERE

A. Section 09900 - Paints and Coatings

B. Section 11510 - TSV Operator

PART 2 - MATERIALS

2.01 DESCRIPTION OF EQUIPMENT

A. Turbine Shutoff Valve shall include the following:

1. Size to be determined by Turbine manufacturer as part of their turbine design, flow-through disk butterfly valve with one double-acting hydraulic operator plus counterweighted lever arm and anchorages. The hydraulic operator shall be in accordance with the requirements of Section 11510 – Valve Operator and Hydraulic Power Unit.
2. Valve bypass line including manually operated upstream isolation valve, hydraulically actuated bypass valve, piping, and fittings.
3. The equipment shall be complete with all parts and components specified and/or required for operation, installation, and maintenance.
4. Minimum required and recommended spare parts. Minimum required spares shall be listed along with the quantity and included in the cost.
5. Special handling equipment and other support equipment, if required, for installation, which are specific to the Equipment Supplier's design and which cannot be readily purchased. All special handling equipment considered necessary shall be provided.
6. Two complete sets of erection and maintenance tools (special tools, if any) needed for the adjustment and normal maintenance of the valve operator and hydraulic power unit. Each set of tools shall be neatly mounted in heavy-duty

steel cabinets provided with locks and suitable for wall mounting. Tools shall be clearly identified as to intended use.

7. One complete set of erection supplies, including nuts and bolts, electrodes, grouting material, seal vulcanizer, alignment checking instruments, special gages, and templates needed for efficient installation of the equipment and for checking the installed equipment.

2.02 OPERATING CONDITIONS

A. The Turbine Shutoff Valve shall be designed for the following operating conditions:

1. Normal Operation:
   a. Continuous operation with the valve in the open position, passing normal turbine flows under normal head.
   b. Operation with the valve in the full open position and maximum transient pressure in the valve water passage. Maximum transient pressure to be determined by analysis, to be performed by the Equipment Supplier's turbine manufacturer.
   c. Closure of the valve against maximum turbine discharge and under maximum head.
   d. Valve in closed position withstanding maximum project static head of 343 ft.
2. Emergency Operation:
   a. Closure of the valve using an operator and counterweighted lever arm against maximum penstock flow of TBD cfs (turbine runaway flow to be provided by turbine manufacturer).

2.03 MODES OF OPERATION

A. The valve shall operate in the following modes of operation:

1. Remote Automatic.
2. Remote Manual.
3. Local Automatic.
4. Local Manual.
5. Automatic Drift Control.
6. Automatic or Manual Emergency Closure.
7. Refer to Section 11510 - Valve Operator and Hydraulic Power Unit for additional details.

2.04 DESIGN AND PERFORMANCE REQUIREMENTS

A. The Equipment Supplier shall furnish the detailed layout and design in conformance with the drawing, specifications, and the following design criteria

B. Design criteria used for the valve design shall ensure that the valve can perform all operations as specified and can be safely operated under any loading condition in the environment for which it is intended.

C. The valve and operating mechanism shall have sufficient capacity at nominal system pressure to move the valve disc smoothly through a full opening or closing stroke in the time and conditions specified herein.

D. Design the valve to operate safely, reliably, and smoothly without binding, excessive vibration, noise, or heat increasing wear of components. The valve shall be designed to prevent vibration and cavitation while operating under the conditions listed in paragraph 2.02.

E. The valve shall be designed for normal opening and closing under approximately balanced head conditions with the turbine wicket gates closed and the penstock upstream of the valve full. The valve will be used for emergency closure, unit dewatering, and maintenance.

F. After dewatering and before opening the valve the turbine downstream of the valve will be filled by opening the bypass line provided across the valve.

G. The valve shall also be designed for emergency closure by gravity through the use of an operator and counterweight lever arm in the event of emergency or turbine runaway under unbalanced head conditions.

H. Coordinate valve design with Valve Operator and Power Unit specified in Section 11510, Valve Operator and Hydraulic Power Unit. A combined hydraulic power unit is to be furnished, suitable for turbine shutoff valve operation as well as turbine governor operations.

2.05 DESIGN PARAMETERS

A. The principal design parameters for the turbine shutoff valve are as follows:

1. Size of valve: TBD diameter.
2. Design head: TBD ft.
3. Normal flow: 0-TBD cfs (based on operating flow range for turbine)
4. Design flow: TBD cfs (to be provided by turbine manufacturer, valve shall be capable of closing under full emergency flow).
5. Maximum allowable “K” factor: 0.16
6. Rate of opening or closure: Shall be coordinated with the turbine and governor design.
7. Operating temperature range: 0 - 120º F.
8. Duty cycle: the Turbine Shutoff Valve will be opened and closed several times a day or open for weeks or months at a time, and then closed for weeks or months at a time.

2.06 ALLOWABLE STRESSES

A. Working stresses, bearing pressure, and other design criteria such as limits of deflection, torsional distortion, and alternating stress shall be determined foremost on the basis of producing a functionally reliable trouble-free and long-life design. Equipment Supplier shall be responsible for an adequate design based on factors proven in practice and shall use lower working stresses wherever deemed necessary or desirable. Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock. The design of the equipment shall include an allowance for earthquake loading for seismic zone 4, in accordance with the UBC.

B. Stress concentration factors shall be used where applicable. Reduction of allowable stresses to compensate for repeated and high cycles of loading is not required.

C. Allowable Stresses for Normal Loading Conditions: Under the most severe conditions of loading expected in normal operation, stresses in the materials shall not exceed the values listed below.

Material	Maximum Allowable Stress for Normal Loading		
	In Tension	In Compression	In Shear
Carbon Cast Steel and Alloy Cast Steel	The lesser of 1/5 U.T.S. or 1/3 Y.S	The lesser of 1/5 U.T.S. or 1/3 Y.S	2/3 Allowable in Tension
Carbon Steel Forgings	1/3 Y.S.	1/3 Y.S.	2/3 Allowable in Tension
Carbon-Steel Plate for Important Stress-Carrying Parts	1/4 U.T.S.	1/4 U.T.S.	2/3 Allowable in Tension
High-Strength Plate Steel for Highly-Stressed Parts	1/3 Y.S.	1/3 Y.S.	2/3 Allowable in Tension
Stainless Steel Components and Other Corrosion Resistant Material except Threaded Fasteners	1/3 Y.S.	1/3 Y.S.	2/3 Allowable in Tension
Threaded Fasteners	1/3 Y.S.	1/3 Y.S.	2/3 Allowable in Tension

D. The design stresses for materials not listed herein shall be selected by the Equipment Supplier, but the maximum stresses in tension or compression shall not exceed one-third of the yield strength or one-fifth of the ultimate tensile strength.

2.07 BEARINGS AND BUSHINGS

A. General: Average bearing pressures shall be calculated by dividing the bearing load by the effective projected area (diameter multiplied by length for round items) of the bearing. Maximum local bearing pressures shall be calculated for unsymmetrically loaded bearings and bushings assuming non-uniform linear pressure distribution along the length of the bearing. When calculating maximum local bearing pressures due to shaft deflection, it shall be assumed that the steel shaft is incompressible and bearing pressures are proportional to the compression of the bearing material.

B. Bronze and Other Nonferrous Bushings: For normal loading conditions, the average bearing pressure shall not exceed 10% of the yield point; the product of bearing pressure in lb/in^2 and circumferential in ft/sec velocity shall not exceed 1400. For overload conditions, the above values may be multiplied by 1.5, and for stalled conditions, the limits may be multiplied by 2.25; however the maximum average bearing pressure in no case shall exceed 25% of the minimum yield strength of materials involved, and maximum local bearing pressure shall not exceed 50% of the minimum yield strength of the materials.

C. Permanent Self-Lubricating Bushings: Average bearing pressure for permanent self-lubricating bearings for normal loading condition shall not be higher than recommended by permanent self-lubricating bearing manufacturer, but in no case higher than 4200 lb/in^2. The allowable average bearing pressure shall not exceed 5000 lb/in^2 for overload conditions. For maximum allowable local bearing pressures, the above values may be increased by 20%.

D. Concrete: Embedded parts in the concrete structure and parts bearing on the concrete structure shall be designed such that stresses in concrete do not exceed the following values:

1. Bearing: 1,000 psi.
2. Shear: 320 psi.
3. Bond: 110 psi (to plain surface)

2.08 DESIGN CRITERIA

A. Pressure-containing, weld-fabricated components shall be designed, fabricated, inspected, and tested in accordance with the requirements ASME BPVC Section VIII, unless otherwise specified. Components shall be stress relieved prior to final machining.

B. Other weld-fabricated components shall be designed, fabricated, inspected, and tested in accordance with the applicable sections of AISC Specification and AWS D1.1, unless otherwise specified. Components shall be stress relieved, as required, to obtain specified or required tolerances.

C. Design of the turbine shutoff valve shall be in accordance with applicable requirements of ANSI/AWWA C504.

D. All full penetration butt welds shall be RT and UT inspected. All remaining welds shall be PT or MT tested. All welds shall be visually inspected. All welds shall be continuous smooth and of good commercial appearance, no undercuts shall be allowed, and all weld splatter shall be removed.

E. The operating mechanism connections, mountings, and other parts of the equipment subject to such forces shall withstand, without damage, the maximum output pressure of the system.

F. The operating mechanism, supports and connections to the valve shall be designed with a minimum safety factor of 5, based on the ultimate strength, or a minimum of 3, based on the yield strength of the materials used.

G. The rated torque capability of the valve operating mechanism shall be at least 25% greater than the calculated or required operator torque based on analysis of the following operating forces. The torque capability of the mechanism shall be sufficient to seat, unseat, and rigidly hold, in any intermediate position, the valve disc under the operating conditions specified.

H. Operating Forces: Calculate combined operating forces for normal and emergency operating conditions based on analysis of the following:

1. Seating or unseating torque: Torque required to overcome the rubber seat friction when the valve disc is being seated or unseated.

2. Bearing friction torque: Torque required to overcome the friction between the valve shaft and the shaft bearings.
3. Dynamic torque: Torque developed by the disc on the valve shaft because of the difference in pressures that exist across the valve disc as a result of flow.
4. Hydrostatic torque: Torque caused by the difference in static head across the valve disc.
5. Hydraulic cylinder friction.
6. Hydraulic system backpressure due to counterbalance valves or other fluid flow resistance features.

2.09 DELIVERY, STORAGE, AND HANDLING

A. The valve and accessories shall be prepared for shipment in accordance with Section 15010 - Basic Mechanical Requirements.

2.10 PROJECT/SITE CONDITIONS

A. Turbine Shutoff Valve will be installed in a below grade concrete vault.

2.11 WARRANTY

A. All equipment shall be guaranteed in accordance with Section 15010 - Basic Mechanical Requirements.

2.12 PRODUCTS

A. Materials and Mechanical Equipment

1. General requirements for materials and mechanical equipment shall comply with Section 15010 - Basic Mechanical Requirements.

B. Material Standards

1. Clearly identify material specifications or standards, including grade, class or type, for each component on Equipment Supplier’s shop drawings. The standard, type, and grade of materials of the equipment except where specified elsewhere in these Specifications shall be selected by Equipment Supplier to suit Equipment Supplier’s design. Materials not specifically designated shall be subject to approval by the Engineer.

C. Acceptable Material Standards

1. Use the following partial list of material specifications, which are acceptable for the intended purposes, as referenced for selecting standard, types, and grades of materials used by Equipment Supplier.

Product-Form	Material Group	Application	Specification
Castings	Carbon Steel	General applications	ASTM A27, Grade 65-35 or better
	Carbon Steel	Pressure-containing Parts and for welding	ASTM A 216, Grades WCB and WCC
	Alloy Steel	High-strength, structural purposes	ASTM A 148, Grade 80-50
	Alloy Steel	Pressure-containing parts	ASTM A217, Grades WC4 and WC5
	Corrosion-Resistant	General applications	ASTM A 743, Suitable Grade
	Alloy Steel	Precipitation hardening material for wheels and rollers	ASTM A 747, Grade CB7-CU1
	Copper Alloy	Sand castings for general applications	ASTM B 584, Suitable grade
	Gray Iron	General purpose	ASTM A 48, Suitable grade
	Malleable Iron	General purpose	ASTM A 47, Suitable grade
Shapes, plate and bars	Structural Steel	General purpose	ASTM A 36
		High strength, low alloy	ASTM A 572, ASTM A 242
Plate	Carbon Steel	Pressure-containing parts	ASTM A 516, Grade 60 or better, Impact tested
	Carbon-Manganese Silicon Steel	Pressure-containing parts	ASTM A 537, Class 1, Impact tested

Product-Form	Material Group	Application	Specification
Plate Cont.	Stainless Clad Carbon Steel	Sealing surfaces not machined	ASTM A 264; with A 285, Grade C base material and A 240, Type 304L cladding for a minimum 20% of thickness
Plate, Sheet and Strip	Corrosion-Resistant Steel	General purpose	ASTM B 766 and ASTM A 176
	Corrosion-Resistant Steel	Fusion-welded Pressure-containing parts	ASTM A 240, Type 304L
	Phosphor Bronze	Bearing plates	ASTM B 100, Alloy C51100
	Nickel-Copper Alloy	Monel	ASTM B 127
Bar	Carbon Steel	Pins and shafts up to 4-in. diameter	ASTM A 576, Grade 1020 or 1030
	Corrosion-Resistant Steel	General Purpose	ASTM A 276
	Hardened Corrosion-Resistant Steel	Shafts and pins	ASTM A 479; ASTM A 564, Type 630
Rod, Bar and Shapes	Brass	General purpose free machining	ASTM B 16
Forgings	Carbon and Alloy Steel	General industrial use	ASTM A 668
	Corrosion-Resistant Steel		ASTM A 473
Pipe	Carbon Steel	General service handrails, special sizes/ superior	ASTM A 53, Grade B ASTM A 53, Grade A

Product-Form	Material Group	Application	Specification
		grades/ pressure vessels	ASTM A 106
Pipe Cont.	Austenitic Stainless Steel	Corrosion-resistant	ASTM A 312
	Copper	General plumbing water	ASTM B 42
Pipe Fittings	Forged Carbon Steel	Flanges, fittings, and valves	ASTM A 105, ASTM A 181
	Wrought Carbon Steel	Elbows, tees, and caps	ASTM A 234
	Stainless Steel	Elbows, tees, and caps	ASTM A 403
Tube	Austenitic Stainless Steel	Machinery component interconnections	ASTM A 269
	Copper	Subject to cleanliness or corrosion-resistant requirements	ASTM B 88, Type K
Bolting	Low Carbon Steel	General purpose	ASTM A 307, galvanized
	High Strength Alloy Steel	Structural joints	ASTM A 325, galvanized
	Stainless Steel	Corrosion-resistant	ASTM A 193
	Naval Brass	Corrosion-resistant	ASTM B 21
Studs	Cold-finished Carbon Steel	Shear connectors (embedded anchors)	ASTM A 108
Rubber Seals	Rubber	Butterfly valve seal	AWWA C 504
Seal Rings	Rubber	O-rings	

2.13 VALVE

A. Valve shall be a horizontal-shaft, rubber-seated, flow-through disk butterfly type. The valve body shall have flanged end connections for attachment of the upstream and downstream penstock. The valve flanges shall be sealed using O-rings.

B. Valve body shall be made of ASTM A516, Grade 60 or better and designed to meet the pressure, flow, and operating requirements specified.

C. Integral valve supports shall be provided for mounting the valve. Furnish required anchor bolts, shims, fasteners, and other parts required for installation.

2.14 VALVE DISC

A. Disc shall be biplanar or lattice type to minimize head loss. The valve disc shall seat at 90 degrees to the axis of the valve body and shall require no torque to hold it in the closed position.

B. Disc shall be made of ASTM A216 WCB and A516, Grade 60 or better with stainless steel seat surfaces on the edge of the valve disc for mating with the rubber seal. The width of the seat surface shall, at a minimum, cover the entire surface wiped by or in contact with the rubber seat.

2.15 VALVE SHAFTS

A. Valve shafts shall be two-piece, stub type inserted into hubs in the valve disc. The valve shafts shall be made of ASTM 276 or ASTM A564.

B. Disc-to-shaft connection shall be done by proven and reliable means using stainless steel pins, lock washers, and nuts. The disc-to-shaft connection shall be a double-eccentric design, such that the valve will tend to drift slowly closed (not quickly close or slam shut) without operating pressure in the operating cylinder.

C. One valve shaft shall be designed for connection to the counterweight lever arm (if applicable) for operating the valve disc.

D. Shaft seals shall be provided where valve shafts project through the valve body and shall be designed to allow replacement of the seals without removing the valve shaft. The seals shall include all clamp rings, Chevron-type seals, packing glands, end covers, thrust ring, and accessories. Clamps, retaining rings, and attachment hardware for the seals shall be stainless steel.

2.16 VALVE SEATS

A. Rubber seats shall be mounted in the body of the valve and designed to permit removal and replacement without removal of the valve disc.

B. Clamps, retaining rings, and attachment hardware for the seal shall be stainless steel.

C. The rubber compound for the seal shall be in accordance with ANSI/AWWA C504.

2.17 VALVE BEARINGS

A. Valve shall be fitted with sleeve-type bearings contained in hubs of the valve body to support the shaft and provide minimum friction during shaft rotation. The bearings shall be made of self-lubricating materials.

B. Valve shall be equipped with thrust bearings, which shall hold the valve disc securely in the center of the valve seat and protect the shaft seal from side-thrust loads developed in the operating mechanism.

2.18 OPERATING MECHANISM

A. The turbine shutoff valves shall be furnished with one double-acting cylinder and counterweighted lever arm mechanism for operating the valve disc. The operating mechanism shall be equipped with adjustable, mechanical, stop limiting devices to prevent over travel of the valve disc in the open and close positions. The limiting devices shall be equipped with dry contacts to be used for annunciation and control circuitry purposes.

B. The operating mechanism shall be made of structural steel and shall be keyed to the valve shaft. The counterweight shall have sufficient weight at the end of the lever arm to ensure complete closure of the Turbine Shutoff Valve under the conditions specified upon loss of oil pressure.

C. The operating mechanism shall include a manually-operated locking mechanism for holding the valve disc in the closed position. The lock shall be capable of withstanding the full operating force of the operating mechanism to prevent opening of the valve when it is being serviced or under any other condition regardless of the operation of controls. The lock shall be independent of the hydraulic cylinders. Limit switches equipped with a Single Pole Double Throw (SPDT) contact shall be provided with the locking mechanism to indicate lock engaged/disengaged.

D. Equip the operating mechanism with a pointer scale indicating disc position.

2.19 END FLANGES

A. Dimensions: The upstream and downstream flanges shall be manufactured to suit the counter flanges on the penstock.

B. Flange Gaskets: 1/8-inch-thick rubber or O-ring, suitable for pressure classification of valve(s).

C. Flange Hardware: Hexagon head, machine bolts and machine studs with hexagon nuts per ANSI/ASME B18.2.1 and B18.2.2. Use bolt and stud lengths to allow thread protrusions of not more than 1/2-inch through nut make-up.

2.20 PENSTOCK EXTENSIONS

A. Provide upstream and downstream extensions made of ASTM A537 Class-1, to connect the TSV to the penstock bypass and to the turbine spiral case, respectively. Design penstock extensions in accordance with ASME Boiler and Pressure Vessel Code, Div. 1. Welding on extensions shall be in accordance with the ASME Boiler and Pressure Vessel Code Sections VIII and IX.

B. Provide dismantling joint or other suitable means between the downstream end of the downstream penstock extension and the inlet section of the turbine spiral case, to facilitate installation and removal of the TSV. Sleeve-type mechanical couplings shall be of the gasketed, sleeve-type design, with diameter to properly fit the pipe. Middle ring (sleeve) thickness and follower (end ring) design shall be determined by the manufacturer. The coupling shall be designed for a working pressure of 70 psi and a transient pressure of 80 psi. The coupling shall be Baker Coupling Company Series 200, Dresser Industries Style 38, Romac Industries Style 400 or equivalent consisting of:

   (1) Middle Ring (Sleeve): Middle ring shall be true circular sections, free from irregularities, flat spots or surface defects. Middle ring shall be formed from plate or milled sections, properly welded, and cold expanded 1% beyond the yield point.

   (2) Follower Rings (End Rings): Follower rings shall be true circular contoured mill sections, one piece, with no weldments other than the butt weld. After welding, follower rings will be cold expanded 1% beyond the yield point. All bolt holes in follower shall be oval.

   (3) Coupling Bolts: Bolts shall be elliptic neck, track head design, with rolled threads. Coupling bolts shall be furnished with Heavy Hex nuts. Bolts shall be electro-zinc plated or have other similar type of corrosion protection.

   (4) Gaskets: Gaskets shall be of the wedged shape design, compounded from materials suitable for the pipeline contents. Compression set, resilience, and cold flow characteristics shall be determined applying the testing requirements of ASTM 2000.

  b. The coupling shall have the same surface preparation and be coated and lined with the same material as applied to the adjacent pipe sections.

C. Pressure taps shall be provided on the downstream penstock extension to measure inlet pressures. Four pressure taps shall be provided on each penstock extension, manifolded together with isolation valves. The pressure taps shall be equally spaced and located plus and minus 45 degrees relative to the horizontal centerline of each extension.

D. Pressure piping shall be provided as shown and specified in Section 15060 – Pipe and Pipe Fittings.

E. Differential Pressure Transmitter: A differential pressure transmitter with associated taps, tubing, and isolation valves shall be furnished and installed. The switch shall provide indication of differential pressure across the Turbine Shutoff Valve and will be used as follows:

1. To provide indication of balanced pressure across the valve and serve as a permissive for opening the valve.
2. To provide indication of high head loss across the valve and serve as a signal for closing the valve in response to penstock rupture.
3. The transmitter shall have a pressure range limit of 100 psid with a calibrated span of 0 to 100 psid. Isolating diaphragms shall be 316 stainless steel and fill fluid shall be silicone. Process flanges and adapters shall be 316 stainless steel. The transmitter output shall be 4-20 mA dc with an accuracy of +/- 0.25% of calibrated span. The transmitter shall be furnished with local zero and span adjustment. The transmitter shall be loop powered with a 24 V dc power supply. Connections to the pressure piping shall be SAE straight thread, O-ring type. The pressure switch shall be provided with a needle shutoff valve and snubber. The transmitter shall be Rosemount 1151DP Series, or equal.

F. Penstock Pressure Transmitter: A penstock pressure transmitter shall be furnished and installed in the penstock pressure tap piping manifold. The transmitter shall have a pressure range limit of 0 to 100 psig with a calibrated span of 0 to 100 psig. Isolating diaphragms shall be 316 stainless steel and fill fluid shall be silicone. Process flanges and adapters shall be 316 stainless steel. The transmitter output shall be 4-20 mA dc with an accuracy of +/- 0.25% of calibrated span. The transmitter shall be furnished with local zero and span adjustment. The transmitter shall be loop powered with a 24 V dc power supply. Connections to the pressure piping shall be SAE straight thread, O-ring type. The pressure switch shall be provided with a needle shutoff valve and snubber. The transmitter shall be Rosemount 1151GP Series, or equal.

2.21 BYPASS LINE

A. A bypass line shall be provided around the Turbine Shutoff Valve, made of ASTM A537 Class-1. All piping, fittings, valves, and appurtenances shall be selected and designed in consideration of the static and transient pressures, high velocities, and turbulence and vibration typical of valve bypass lines in this application. The line shall be complete with gate valve, bypass valve, dismantling joint, pipe fittings, and appurtenances. All components required for installation, including bolts, nuts, gaskets, shall be provided.

B. Gate valve: Provide manually-operated gate valve upstream of the TSV bypass valve, for isolation and maintenance of the TSV bypass valve.

C. Pipe and fittings: Piping and fittings shall be extra strong grade, for rigidity and longevity. Refer to Section 15060 – Pipe and Appurtenances for specification requirements.

D. Bypass valve: angle needle valve or other suitable type proven in this specific application.

E. Bypass valve operator: hydraulic operator sized for at least 125% of the maximum required torque to operate the bypass valve under worst-case conditions. Provide operator with local/remote switch, local open and close pushbuttons, and local open and closed indicating lights. Provide operator with manual handwheel and manual declutch lever to provide for local operation by handwheel. Size gearing for handwheel so maximum required force at the handwheel perimeter does not exceed 40 lbs.

F. Provide limit switches for valve Close/Open indication.

2.22 SPARE PARTS

A. Equipment Supplier shall furnish the following spare parts or materials for each valve in the quantities listed below:

Item	Quantity
Packing	2
Seal	2
O-rings	2

2.23 SHOP ASSEMBLY AND TESTING

A. The valve and operating mechanism shall be completely assembled in the shop to verify design, fabrication, and machining for proper alignment, fit, and clearances. Properly match-mark, identify, and dowel parts to ensure correct assembly and alignment for field installation. Where necessary, furnish dowels for field installation after shop assembly and drilling.

B. Measure and record controlling dimensions and clearances of assemblies on illustrated shop inspection forms, showing both the design drawing dimensions and the actual measured dimensions.

C. Shop inspections and tests shall be made in the presence of the Engineer, unless otherwise authorized in writing. Provide 14 days notice to Engineer prior to the date for inspections and tests.

D. Perform pressure, leakage, and operating tests and submit test results. Equipment Supplier shall submit for review an outline of proposed test procedures and test plans to demonstrate fulfillment of the requirements of the Specifications.

E. Shop Pressure Tests: Close both ends of the valve with bulkheads and apply a hydrostatic test pressure of 1.5 times the maximum static pressure on both sides of the disc for a minimum of one hour. Under this test no leakage will be allowed and none of the parts shall show any evidence of distress.

F. Shop Leakage Tests: After the pressure test has been satisfactorily completed, apply a hydrostatic pressure of 1.0 times the maximum static head on the upstream side of the disc, with the downstream side of the disc at atmospheric pressure for a minimum of 1 hour. Under this test the valve shall be drop tight with zero leakage. Check the valve seal and valve packing for leakage.

G. Shop operating tests: After successful completion of the shop pressure and leakage tests, fully assemble the valve and operating mechanism to demonstrate that the complete assembly functions properly without interference and binding. The valve and operating mechanism shall be operated at least three times from the fully closed to the fully opened position and back to fully closed to confirm specified operation of the valve.

H. Correct all defects, distortion, and leakage that developed during testing to the satisfaction of the Engineer. Repeat tests if, in the opinion of the Engineer, further tests are warranted. All necessary repairs, adjustments, and retesting shall be performed at no additional cost to the Owner

2.24 TEST REPORTS

A. Prepare and submit shop test reports in accordance with Section 15010, Basic Mechanical Requirements.

2.25 PAINTING

A. All exposed exterior surfaces of assemblies and equipment except stainless steel, synthetic rubber, and plastic, shall be shop primed and coated as specified in Section 09900 PAINTING unless the equipment is given a standard factory finish as allowed by other paragraphs of this specification. Insofar as is practicable, the complete coating system shall be applied to individual components and items before assembly to ensure complete coverage and maximum protection against corrosion. Equipment which have a factory-finished coating do not need to be recoated. Chips, scratches, and other damage to shop-applied painted surfaces shall be repainted in the field.

2.26 IDENTIFICATION

A. All pipe and equipment shall be labeled to designate service, direction of flow, pipe size, operating pressures, and setpoints. Labels shall be located near equipment and valves. Valve handwheels and operating levers shall be painted according to the following color schedule to indicate normal operating position:

Closed:	Green
Open:	Red
Open or Closed:	Yellow

PART 3 - EXECUTION

3.01 SHOP ASSEMBLY

A. Each valve shall be completely assembled, tested and inspected in Equipment Supplier's shop prior to delivery to the Project site. Adjoining components shall be fitted, doweled and bolted together to ensure proper fit and alignment during field erection and assembly. Assembled components shall be shop-welded in their final positions, as much as shipping limitations and field installation conditions will permit.

B. Shop assembled components shall be inspected for accurate fit, correctness of dimensions and clearances, accuracy of alignment and ease of movement. Parts shall be properly match-marked, identified, and doweled to ensure correct assembly and alignment in the field. Errors, misalignments and other quality deficiencies shall be corrected and the corrections verified before shipment.

C. Controlling dimensions and small clearances of the assemblies shall be measured and recorded on illustrated shop inspection forms, showing both the design drawing dimensions and the actual measured dimension.

D. The Owner will periodically witness and/or inspect the Work in progress at the Supplier's shop at no additional cost.

E. Equipment Supplier shall maintain a checklist to make sure all work tasks are completed and to record when they were completed. As the Work progresses, the list shall be modified to include any items missed on the original list or remove any items not required. The checklist shall include any testing or adjustments that will be required before the unit is started or released for operation. Checklist shall provide for sign-off by the Owner at critical points of progress, including, but not limited to, milestones, hold points, major witness inspections, and testing.

F. Where it is not practicable to include mating components into an assembly, during shop testing, they may be assembled separately, subject to the Owner's approval. If mating components are assembled separately, suitable provisions simulating the excluded mating parts shall be made in the sub-assembly as required to assure that all parts will fit up properly when the equipment is assembled in the field.

3.02 FACTORY ACCEPTANCE TESTING (FAT)

A. Equipment Supplier shall perform mechanical, electrical, functional and performance tests to demonstrate that the valves and accessories are fully functional and meet specified or guaranteed performance requirements.

B. The Equipment Supplier shall notify the Owner of the testing schedule no later than three (3) weeks before the scheduled testing date, to allow optional witnessing by the Owner upon completion. Failed tests shall be reported with the mitigation action taken.

C. Equipment Supplier shall perform hydrostatic and leakage tests on all fluid pressurized systems and pressure containing parts including, but not limited to, valve body, upstream spool piece, expansion joint, bypass system, and servomotor cylinder. A combined list of such pressure tests shall be prepared by the Equipment Supplier. The list shall include design pressures, test pressures, and test dates, and when completed it will serve as an inspection record that is to be submitted to the Owner.

D. Hydrostatic tests shall be 150% of design pressure and applied for 60 minutes. Under the hydrostatic pressure test none of the parts shall show evidence of distress and welded joints, and fit-up joints shall be leak tight. The hydrostatic test shall be performed with an upstream and downstream bulkhead and the valve disc partially open. After the hydrostatic pressure test has been satisfactorily completed, reduce the internal pressure to the design pressure to perform a leakage test for 60 minutes. The leakage test shall be performed with the downstream bulkhead removed and the valve disc fully closed. Under the leakage test all seals, packing and mechanical joints and leak paths shall be periodically checked for leakage. Leakage shall be zero.

E. Equipment Supplier shall trial operate the valve in the dry and in the wet against valve design pressure.

F. Inspections

1. The finished valve assemblies and sub-assembles shall be given a complete inspection prior to shipment. Checks and measurements made during the inspection shall include dimensional checks, clearances, surface finish, and nondestructive examinations. Measurements that are outside the tolerances permitted by specified standards and approved drawings may be cause for rejection.
2. Final measurements: Recorded on data sheets prepared by the Equipment Supplier and signed by representatives of the Equipment Supplier, Owner, and Owner's Engineer. Copies of all data sheets shall be provided for Owner's permanent records.

G. Operational Tests

1. Each assembled valve shall be operated through their full movement a minimum of three open-close cycles to demonstrate that the disc and servomotor and counterweight mechanism function properly without interference or binding.
2. The servomotor assembly shall be shop tested for any oil leaks with the disc in motion with an oil of governor oil viscosity under the maximum pressure that will exist in normal operation. The servomotor shall be leak-free.
3. To demonstrate that the counterweight will guarantee the closure of the valve under normal and emergency conditions, and not deform or fail to close, a test shall be performed in the shop using equipment to simulate the actual normal and emergency operating conditions. Following the test, the Equipment Supplier shall inspect the valve to ensure no deformations or damages have occurred from the test. The test results and a description of the test rig shall be submitted to the Owner for approval.

H. Thirty days (30) prior to the factor acceptance test, the Equipment Supplier shall provide detailed factory assembly and test procedures for review and approval.

I. Following the factory acceptance test, within ten (10) days of testing, the Equipment Supplier shall provide the following to the Owner for review and approval. The

Equipment Supplier shall not ship the equipment prior to the Owner's acceptance of the following reports and requirements of this specification:

1. Submit a detailed quality docket for all shop and factory testing.
2. The Equipment Supplier shall provide to the Owner photos of assembled equipment prior to shipping.

3.03 INSTALLATION

A. Installation will be performed by a general contractor under a separate contract with the Owner.

B. Equipment Supplier shall provide detailed installation drawings, procedures, and acceptance criteria for installation that will be implemented by the general contractor.

C. Equipment Supplier shall provide the services of a trained field service representative to advise and assist during installation, field testing, and commissioning of the valve, when requested by the Owner. All installation checksheets shall be reviewed and signed as accepted by Equipment Supplier's field service representative.

D. The valve Equipment Supplier's representative shall certify correct installation, in compliance with installation requirements before proceeding with field testing and commissioning.

3.04 PACKAGING AND SHIPMENT

A. The valve and all appurtenances shall be shipped and stored in accordance with the manufacturer's instructions and per the Owner approved Shipping and Delivery Plan.

B. Assembly instructions and the operation and maintenance manual shall be shipped with the valves.

C. The Contractor shall coordinate the delivery of the equipment to the project site or storage location as specified by the Owner. All equipment shall be shipped FOB to the location specified by the Owner.

D. The Contractor shall ensure that the equipment is packaged and protected such that no damage occurs during shipping.

3.05 INSTALLATION CHECKS AND TESTING

The Equipment Supplier will support the installer with performing the tasks described in this subsection. The installer will perform the following with support from, direct supervision and active engagement of the Equipment Supplier's qualified commissioning engineer.

A. Perform tests and supply labor, materials, equipment, and devices for execution of the tests. Notify Engineer one week in advance of any tests.

B. Supply test instruments and equipment. Use test equipment that is certified as calibrated prior to testing.

C. Check equipment for proper installation and adjustment, including gauges, instruments, controls, flow indicators and switches, valves, strainers, pumps, fans and lubricating devices prior to testing. Calibrate all gauges, switches, instruments, and similar devices and provide Engineer copies of calibration records.

D. The installation checks and testing specified herein may be augmented if deemed advisable by the Equipment Supplier's Service Department(s). The following requirements are specified hereafter to establish the minimum extent of checks and testing required.

E. Prepare and submit for approval a check-off list procedure for start-up. Sign off each item indicating that it is ready for use in the start-up. Perform the following checks and tests after installation is complete:

1. Adjust valve for uniform opening and closing.
2. Check and backwash pressure tap piping for obstructions and proper functioning.
3. Check gauges, instruments, controls, valves, lubricating devices, flow indicators, filters, pumps, etc.
4. Calibrate gauges, instruments, controls, temperature devices, meters, indicators, and associated electrical and mechanical devices.
5. Perform operation tests on relays, indicators, thermostats, limit switches, resistance temperature detectors, and flow switches to verify correct calibration, adjustment, and operational readiness.
6. Inspect valve, and auxiliary equipment to be certain that all foreign matter has been removed.
7. Check field wiring to verify conformance with the Drawings, Shop Drawings, and schematic wiring diagrams; to ensure proper phasing and polarity of all power conductors; and to confirm that cable shields are grounded only at the points indicated on the Drawings.
8. Check electrical controls by trial operation of control equipment after wiring is completed to ensure that each interlock and control function operates according to the connection diagrams, as well as in accordance with the manufacturer' schematics and operating instructions.

3.06 FIELD TESTS AND INSPECTIONS

A. The Equipment Supplier shall be responsible for all field testing and commissioning activities related to all equipment under the Supplier's scope of supply, including all labor, materials, instruments and test equipment, instrument calibration, and the cost of test engineer(s). Data collection shall be electronic.

B. The general contractor and the Owner's plant staff will assist with the field testing and commissioning under the direction of the Equipment Supplier's field representative(s). The participation of the Owner and/or the general contractor in testing and commissioning activities shall not relieve the Supplier of its responsibility for the proper execution of the tests.

C. The Equipment Supplier and general contractor shall cooperate with Owner to establish mutually satisfactory dates for testing and commissioning activities.

D. The Equipment Supplier shall prepare and submit detailed test procedures to the Owner for review and approval. Each valve shall be tested by the Equipment Supplier in accordance with the procedures established in Owner-approved test procedures.

E. The Equipment Supplier shall perform testing and commissioning to demonstrate compliance with specified requirements, performance guarantees and expected operational characteristics. The valve operational tests shall be performed in conjunction with the turbine-generator operational tests. Basic operation data shall be recorded.

F. Field Pressure Test: Field test components and devices subject to penstock water pressure at 1.5 times the design working pressure or maximum static head. Any equipment that might be damaged by this pressure shall be isolated or removed to prevent damage. The test pressure shall be maintained for 1 hour. All welded, flanged, and threaded connections shall be carefully examined for leakage. No leakage will be permitted. Repair and retest any leaks.

G. Installation Measurements and Records: Submit completed check sheets and installation measurements of alignment, levels, concentricity, and plumbness.

H. Start-up and initial operation

1. Provide necessary personnel to perform operating functions during start-up and initial operation.
2. During testing, correct items identified as being defective or requiring adjustment.

I. Initial Start-Up:

1. The hydraulic power unit shall have been inspected and deemed operational, in accordance with Section 11510 — Valve Operator and Hydraulic Power Unit.

J. Initial Dry Operation: Perform the following checks and adjustments with the penstock dewatered.

1. Operation of valve timing.
2. Operation of starting and stopping controls, including emergency shut-down devices.
3. Operation of switches.
4. Setting of indicators, thermometers, pressure gauges, electrical indicating instruments, and other devices.
5. Test and adjust automatic control sequencing and operation.
6. Test and adjust valve output controls and remote controls for proper operation.
7. Observe and record valve behavior during test of valve closure.
8. The valve and hydraulic system shall be tested by operating the valve through a minimum of four complete cycles. During each test operation, the hydraulic lines and components shall be inspected for evidence of leakage. The pressure in the

supply and return lines for each direction of operation shall be read and recorded. Response of components to operation of applicable controls shall be inspected to ensure that all connections have been made properly. Flow control valves shall be checked and adjusted as required to conform to indicated operating time requirements. Sequence valves shall be inspected and adjusted as required to obtain the indicated sequence of operation. Chokes in pilot circuits of pilot-operated valves shall be adjusted to obtain smooth, shock-free operation.

K. Initial Wet Operation:

1. Normal closure/open (3 close/open cycles minimum) – This includes operation and start up using the bypass system.
    a. Operation of valve timing.
    b. Observe and record valve behavior during test of valve closure against 0, 25, 50, 75, and 100% gate opening, unless otherwise decided by the Owner and the Equipment Supplier.
    c. Measure and record valve and hydraulic system behavior during closure tests.
    d. Make any adjustments at each test point before proceeding with the next test.
2. Emergency closure – The emergency closure test (i.e., dynamic closure against flow under head) shall be performed at speed-no-load, 25%, 50%, 75% and 100% gate, unless otherwise decided by the Owner and the Equipment Supplier
    a. Operation of valve timing.
    a. Observe and record valve behavior during test of valve closure against 0, 25, 50, 75, and 100% gate opening, unless otherwise decided by the Owner and the Equipment Supplier.
    b. Measure and record valve and hydraulic system behavior during closure tests.
    c. Make any adjustments at each test point before proceeding with the next test.

3.07 TEST REPORTS

A. Test Reports: A complete report (or reports) of the field tests performed on the equipment, including initial operation and performance tests shall be furnished within 30 days of commissioning the unit. The report shall include a description of the items tested and of the instrumentation; a list of test personnel; calibrations of measuring equipment; test procedures; tabulations of measurements taken; sample calculations; test results, including final adjustments, settings, and valve flow performance curves; and a discussion of the test results and conclusions.

3.08 EQUIPMENT SUPPLIER'S FIELD SERVICE REPRESENTATIVE

A. The Equipment Supplier shall provide an experienced Field Service Representative who is regularly employed by the valve manufacturer to supervise the installation, start-up, adjustment, operation, and testing of the equipment provided. Equipment Supplier's Representative shall be fluent in written and spoken English. The Equipment Supplier's Representative shall furnish a signed statement stating that the final installation and start-up of the valve has been inspected, witnessed, and complies fully with the manufacturer's warranty requirements. The Equipment Supplier's Representative shall also instruct the Owner's operating staff in the operation and maintenance features of the equipment. Alternatively, the requirements of this section may be provided by the valve manufacturer, pending approval by the Engineer. Refer to Section 15010, Basic Mechanical Requirements, for additional requirements.

END OF SECTION

SECTION 11510
VALVE OPERATOR

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section covers the following items for the Turbine Shutoff Valve (TSV):

1. Valve Operator.
2. Control Panel for TSV operation
3. Hydraulic Piping and valves.
4. Service Departments

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05000 – Materials and Workmanship

B. Section 09900 – Paints and Coatings

C. Section 11500 – Turbine Shutoff Valve

D. Section 15080 – HPU

E. Section 15970 – Turbine Governor

1.03 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1. American National Standards Institute (ANSI)

ANSI C80.1	Rigid Steel Conduit - Zinc Coated
ANSI T2.24.1	Hydraulic Fluid Power – Systems Standard for Stationary Industrial Machinery First Edition

2. American Society for Testing and Materials (ASTM)

ASTM A 106	Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A 108	Steel Bars, Carbon, Cold-Finished, Standard Quality
ASTM A 181	Carbon Steel Forgings for General-Purpose Piping
ASTM A 182	Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A 193	Alloy-Steel and Stainless-Steel Bolting Materials for High-Temperature Service
ASTM A 194	Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 216	Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A 234	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 266	Carbon Steel Forgings for Pressure Vessel Components
ASTM A 312	Seamless and Welded Austenitic Stainless-Steel Pipes
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 325M	High-Strength Bolts for Structural Steel Joints (Metric)
ASTM A 331	Steel Bars, Alloy, Cold-Finished
ASTM A 354	Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
ASTM A 516	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 519	Seamless Carbon and Alloy Steel Mechanical Tubing
ASTM A 536	Ductile Iron Castings

ASTM A 564	Hot-Rolled and Cold-Finished Age-Hardening Stainless-Steel Bars and Shapes
ASTM A 576	Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A 659	Steel, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled Sheet and Strip, Commercial Quality
ASTM A 705	Age-Hardening Stainless and Heat-Resisting Steel Forgings
ASTM A 789	Seamless and Welded Ferritic/Austenitic Stainless-Steel Tubing for General Service
ASTM B 505	Copper-Base Alloy Continuous Castings
ASTM B 584	Copper Alloy Sand Castings for General Applications
ASTM D 3951	Commercial Packaging
ASTM F 844	Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM G 85	Modified Salt Spray (Fog) Testing

3. American Society of Mechanical Engineers (ASME) International

ASME B16.11	Forged Fittings, Socket-Welding and Threaded
ASME B31.1	Power Piping
ASME B36.19M	Stainless Steel Pipe
ASME B40.1	Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPV VIII	Boiler and Pressure Vessel Code; Section VIII, Div 1 Pressure Vessels Division 1 - Base Coverage
ASME Y32.10	Graphical Symbols for Fluid Power Diagrams

4. American Welding Society (AWS)

AWS D1.1	Structural Welding Code Steel

5. National Electrical Manufacturers Association (NEMA)

NEMA ICS 1	Industrial Control and Systems
NEMA ICS 2	Industrial Control and Systems Controllers, Contractors, and Overhead Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA ICS 6	Industrial Control and Systems Enclosures
NEMA MG 1	Motors and Generators
NEMA RN 1	Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

6. National Fire Protection Association (NFPA)

NFPA 70	National; Electrical Code (NEC)

7. National Fluid Power Association (NFLPA)

NFLPA B93.2	Fluid Power Systems and Products – Glossary
NFLPA B93.5M	Practice for the Use of Fire Resistant Fluids in Industrial Hydraulic Fluid Power Systems
NFLPA B93.19M	Hydraulic Fluid Power - Particulate Contamination Analysis - Extraction of Fluid Samples from Lines of an Operating System
NFLPA T3.10.8.8 R1	Hydraulic Fluid Power - Filters - Multi-Pass Method for Evaluating Filtration Performance
NFLPA T3.16.2 R1	Hydraulic Fluid Power - Design for Nonintegral Industrial Reservoirs

8. Society of Automotive Departments (SAE)

SAE ARP 598B	Determination of Particulate Contamination in Liquids by the Particle Count Method
SAE J514	Hydraulic Tube Fittings
SAE J1165	Reporting Cleanliness Levels of Hydraulic Fluids

9. Underwriters Laboratories (UL)

UL 6	Rigid Metal Conduit
UL 50	Enclosures for Electrical Equipment

1.04 SUBMITTALS

A. Submit in accordance with Section 01300 – Submittals.

B. Manufacturer's Data: Submit material lists, material certificates, catalog data, product specifications and descriptive literature, and performance data for items provided.

C. Shop Drawings: Certified drawings showing principal features, construction, and pertinent details of items provided including, but not limited to, hydraulic piping between HPU and TSV hydraulic components, detailed piping layout, and valve operating cylinder assembly. Shop drawings shall also include hydraulic and electrical schematics and elevation drawings of control panels. Drawings shall show all necessary dimensions and fabrication details, including the type and grade of materials, details of welded and bolted joint connections, tolerances on fits and clearances, nondestructive examinations, and all field joints.

D. Schematic and wiring diagrams for the electrical control systems showing all component interconnections for the control, monitoring and protective circuits. Control panel drawings shall clearly identify all internal wires for ease of identification when referring to schematic diagrams. Drawing legends shall be furnished to identify all components and wiring.

E. Design and Performance Requirements: Submit design computations for items designed by Equipment Supplier.

F. Detailed step-by-step procedures and drawings for all of the following equipment to be furnished: Site unloading, handling, storage and maintenance, field assembly, and installation.

G. Engineering Data.

1. Calculations, engineering data, analyses of the following:
    a. Servomotor force calculations.
    b. Pressure drop calculations in hydraulic circuit.
    c. Hydraulic oil specifications.

H. Submit Quality Assurance/Control as per Specification Section 01400 - Quality Assurance.

1. Nondestructive Examination (NDE) procedures and specifications.

2. Shop assembly and factor test procedures with checksheets.

3. Factory Test and Quality Control Reports including pertinent records of tests, measurements, and inspections made during fabrication.

4. Installation drawings, procedures and checksheets.

5. Cleaning and Flushing Procedures.

6. Detailed step-by-step Field Testing and Commissioning Procedures with checksheets.

7. Field Test Reports including pertinent records of field tests, measurements, and inspections made during installation and testing.

8. Complete O&M manual (electronic and hardcopy) manuals in accordance with Section 01300 - Submittals.

1.05 DESCRIPTION OF EQUIPMENT

A. Valve operator and hydraulic power unit shall include the following major subassemblies:

1. Hydraulic cylinder assembly.

2. Cylinder assembly mounting and support structure.

3. Control cabinet, controls, electrical equipment, and accessories.

4. Connecting piping and accessories.

B. The equipment shall be complete with all parts and components specified and/or required for operation, installation, and maintenance.

C. Special handling equipment and other support equipment, if required, for installation, which are specific to the Equipment Supplier's design and which cannot be readily purchased. All special handling equipment considered necessary shall be included and listed in Spare parts.

D. Two complete sets of specialty erection and maintenance tools if needed for the adjustment and normal maintenance of each valve operator and hydraulic power unit. Each set of tools shall be neatly mounted in heavy-duty steel cabinets provided with locks and suitable for wall mounting. Tools shall be clearly identified as to their intended use. The list of tools offered shall be included in Equipment Supplier's bid.

E. One complete set of erection supplies, including nuts and bolts, fasteners, electrodes, grouting material, adhesives, lubricants, seal vulcanizer, alignment checking instruments, special gages, and templates needed for efficient installation of the equipment and for checking the installed equipment.

1.06 OPERATING CONDITIONS

A. The valve operator shall be designed for the following operating conditions.

1. Normal Operation:
   a. Continuous operation with the Turbine Shutoff Valve in the open position passing normal turbine flows under normal head.
   b. Gravity closure of the Turbine Shutoff Valve against maximum turbine discharge, maximum head according to turbine manufacturer design.
   c. Valve in closed position withstanding maximum static head of 159.0 ft.

2. Emergency Operation:
   a. Gravity closure of the Turbine Shutoff Valve using an operator and/or counterweighted lever arm against maximum penstock flow as provided by turbine manufacturer during runaway condition.

1.07 OPERATING REQUIREMENTS

A. Operating Modes: The Turbine Shutoff Valve shall be designed for manual and auto control modes in both remote or local operations.

B. Manual Control:

1. Normal: In this mode of operation the "System Mode" selector switch will be in the "Manual" position to allow manual starting/stopping of pump motors and open/close operation of pushbuttons to manually operate the Turbine Shutoff Valve. Interlocks shall be provided to prevent out of sequence operations.

2. Emergency: A separate circuit shall be provided for emergency closure of the TSV by depressing the "Emergency Close" pushbutton at the local control panel or by receiving a remote input signal from the Owner's SCADA system. The emergency close command shall override all interlocks except the interlock for the mechanical locking device.

C. Auto Control: In this mode of operation the “System Mode” selector switch will be in the “Auto” position to allow automatic operation of the valve. The valve will normally be operated with the selector switch in the “Auto” position. The control system shall be designed for the following automatic operating modes:

1. Drift Restoring: A drift control circuit shall be provided to automatically restore the Turbine Shutoff Valve to its full open position due to leakage in the hydraulic system. The drift control circuit shall activate whenever the valve drifts past 50% of the valve manufacturer’s maximum recommended drift setting. Valve drift sensing signal will come from a proximity switch integral with the hydraulic cylinder. The restoring circuit shall incorporate a timer, which shall be field adjustable. Failure to restore the valve to its full open position within a predetermined time shall illuminate the “Drift Trouble” light on the control panel.

2. Emergency Closure: An emergency closure circuit shall be provided to automatically close the Turbine Shutoff Valve if the turbine-generator reaches runaway speed. Unit speed signal will come from a toothed wheel and speed pickup assembly provided by Turbine design manufacturer. The overspeed set point shall be field adjustable. The emergency closure circuit shall incorporate a timer, which shall be field adjustable. In the event that the speed signal sustains itself at the setpoint for a predetermined time the valve shall close and the “Turbine-Generator Overspeed” light on the control panel shall illuminate.

D. Interlocks:

1. An interlock shall be provided to prevent normal opening and closing of the Turbine Shutoff Valve until the following conditions are met:
   a. The turbine wicket gates are closed. The wicket gates closed contact shall be provided by the Turbine design manufacturer.
   b. The penstock pressure transmitter is equal to a predetermined setpoint (indicating that the penstock is full). The penstock pressure signal shall originate from the penstock pressure transmitter specified in Section 11500 – Turbine Shutoff Valve. The “Valve Balanced Pressure” indicating light shall illuminate when differential pressure across the closed Turbine Shutoff Valve reaches a predetermined setpoint.
   c. The valve mechanical locking device is disengaged. The “Valve Lock On” and “Valve Lock Off” indicating lights shall illuminate when limit switches in the locking mechanism are engaged or disengaged.

E. Control switches, indicating lights, and digital readouts shall be provided as specified below.

1. Oil Pressure Switches: To signal low and high oil pressure in line leading to hydraulic cylinder and illuminate the corresponding “Low Oil Pressure” and “High Oil Pressure” indicating light.

2. Emergency Closure: The “Emergency Closure” indicating light shall illuminate when the emergency close pushbutton on the local control panel is depressed or when a remote signal from the powerhouse is received.

3. Valve Differential Pressure: The “Valve Differential Pressure” digital readout shall be interconnected to the differential pressure transmitter providing a 4-20 mA signal, as specified in Section 11500 – Turbine Shutoff Valve, corresponding to differential pressure across the turbine shutoff valve.

4. Penstock Pressure: The “Penstock Pressure” digital readout shall be interconnected to the pressure transmitter providing a 4-20 mA signal, as specified in Section 11500 – Turbine Shutoff Valve, corresponding to penstock pressure.

F. Proximity switches integral to the hydraulic cylinder shall automatically stop the TSV motion in the full open and full close positions and illuminate valve “Open” and “Close” lights. When the valve is in any partially open position, the valve position “Intermediate” light shall be illuminated.

G. Proximity switch integral to the hydraulic cylinder shall automatically initiate the drift restoring controls.

H. Remote Control Contacts: The general provisions listed below for remote interface shall be made in the local control panel. Terminal blocks shall be provided for connection of all external cables.

1. Output Status Signals: The following output signals shall be provided as part of the design for interconnection with the control system.
   a. Valve Position: Open/Close/Intermediate Position.
   b. Drift Control Trouble.
   c. Power: On/Off
   d. Emergency Closure.
   e. Penstock Pressure: 4-20 mA dc
   f. Valve Differential Pressure: 4-20 mA dc
   g. Manual Lock Position: Open/Close.
   h. System Operation: Local/Remote.
   i. System Mode Position: Manual/Off/Auto

1.08 DESIGN AND PERFORMANCE REQUIREMENTS

A. The general arrangement and location of the valve operator (hydraulic cylinder) and hydraulic power unit and system for operation of the Turbine Shutoff Valve shall be developed by the Equipment Supplier in consideration of clearances necessitated by the structure or other equipment, maximum overall dimensions, and other pertinent features. The Equipment Supplier shall furnish the detailed design in general conformity with these Contract Documents. Equipment Supplier shall pay particular attention to space constraints and access provisions.

B. Design criteria used for operator and hydraulic system design shall ensure that the operator and system can perform all operations as specified over a long life with minimal inspection and maintenance and can be safely operated under any loading condition in the environment for which it is intended.

C. The valve operator mechanism shall have sufficient capacity at nominal system pressure to move the valve smoothly through a full opening or closing stroke in the time and conditions specified by the Turbine design manufacturer with minimum operating oil pressure.

D. Unless otherwise specified, all applicable requirements of NFPA and ASME Code, Section VIII, Division I shall apply for cylinders and hydraulic accumulators. NFPA and ASME Standards shall also apply for piping and accessories, and AISC Standards shall apply for cylinder mountings, support structures, and base frames.

E. Design the valve operator and hydraulic power unit to operate safely, reliably, and smoothly without binding, vibration, noise or heat.

F. The valve operator shall be designed for single -acting hydraulic operation, plus gravity closure through the use of a counterweighted lever arm for the TSV only.

G. Control switches and alarm lights shall be provided to indicate malfunctioning components of the operator.

H. The equipment shall be complete with all parts and components specified and/or required for its operation, installation, and maintenance including items and devices not specifically called for in the Drawings and Specifications but necessary to provide a complete and operational system.

I. Hydraulic operator parts and components, such as seals, gaskets, pumps, valves, and hoses, that are normally or may accidentally come in contact with hydraulic fluid shall be compatible with the selected hydraulic fluid. Hydraulic operator parts and components that are permanently or occasionally submerged in water, or that might be exposed to splash water or humid conditions, shall be adequate to resist without damage the acting water pressure and the corrosive and other effects of submergence and exposure.

J. To prevent galvanic corrosion, non-metallic insulators shall be used between dissimilar metals.

1.09 DESIGN PARAMETERS

A. The principal design parameters for the valve operator and hydraulic system are as follows, the design parameters may be adjusted as required to values agreed upon by the Owner to reduce the footprint of the equipment:

1. Design pressure: 1000 psi
2. Maximum working pressure: 1000 psi
3. Operator stroke: determined by valve manufacturer.
4. Rate of Opening and Closure: Coordinate with turbine design manufacturer.
5. Operating temperature range: 0 - 130º F.
6. Duty cycles: Up to 4 cycles per day (typically) or greater.
7. Main Power Supply: 480V AC
8. Control Circuit Power Supply: 120V AC
9. Refer to Section 11500 for additional design parameters pertaining to the turbine shutoff valve which may have a bearing on valve operator and hydraulic system design.

1.10 DESIGN CRITERIA

A. Hydraulic Cylinder Assembly

1. The cylinder shall be sized on the basis of worst-case operation of the valve under the minimum expected cylinder pressure with a safety factor of 125%. The factor of safety shall be considered for all disc positions, as both the moment arm and the required operator torque vary with disc position.
2. Operator connections, mountings, and other parts of the equipment subject to such forces shall withstand, without leakage or damage, the maximum output pressure of the system.
3. The hydraulic cylinders shall be designed to withstand the maximum operating pressure in the system with a factor of safety of 5 based on the

ultimate strength of the material or 3 based on the yield strength of the material. A factor of safety of 3 shall be applied to the compression load when designing the hydraulic cylinder and piston rod to resist buckling.

4. Hydraulic cylinder assembly shall be designed so that when the valve is erected exactly to the nominal design geometry, the piston rod shall have an available overstroke in addition to the stroke required for complete rod extension to fully open or close the valve. This overstroke measured along the piston rod travel shall be not less than 1.25 in.

5. Components for which the ASME Code is not applicable shall be designed to provide a minimum factor of safety of 2, based on the yield strength of the materials used.

6. The ratio of stroke length to piston outside diameter shall not exceed 60/1.

7. The rod factor of safety under maximum compressive force shall be 4.5:1.

8. Structural items associated with the hydraulic cylinder shall be designed to withstand the maximum force exerted by the hydraulic cylinder plus any dead loads with a minimum factor of safety of 2 based on the yield strength of the materials used.

9. When checking design of various parts of the cylinder assembly, including piston rod, piston rod eye, and cylinder support structure, it shall be assumed that the piston is in the most unfavorable position (extended, retracted, or between end positions) and that the disc is blocked or the piston is driven against either one of the cylinder heads.

B. Hydraulic Oil Piping

1. Piping shall conform to the requirements of ANSI B31.3. The piping size shall be selected so that there is negligible pressure loss between the HPU and equipment servomotors. All flexible connections including hoses shall be of the same nominal size as the rigid piping.

2. Fluid flow velocity in all parts of the system shall be limited to 15 ft/s for pressure lines and 4 ft/s for suction lines and return lines to the reservoir.

C. Hydraulic Oil

1. For ease of stocking the oil, the governor and TSV hydraulic oil type shall be identical to the existing three units. The existing units use **<u>Shell Turbo T68</u>** oil.

D. Miscellaneous Design Criteria

1. Shop Connections: Shop connections shall be designed for assembly by means of welding or by bolting.

2. Welded Connections: Design of welded connections shall be in accordance with the applicable provisions of AWS D1.1 except that provisions for repeated stress will not be required. Hydraulic cylinder shall be welded in accordance with ASME BPV, Section VIII, Division 1. Piping shall be welded in accordance with ASME B31.1.

3. Structural Bolted Connections: Structural bolted connections carrying primary loads shall be made with ASTM A 325 bolts.

1.11 ALLOWABLE STRESSES

A. Working stresses, bearing pressure, and other design criteria such as limits of deflection, torsional distortion, and alternating stress shall be determined foremost on the basis of producing a functionally reliable, long-life and trouble-free design. Equipment Supplier shall be responsible for an adequate design based on factors proven in practice and shall use lower working stresses wherever deemed necessary or desirable. Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock. The design of the equipment shall include an allowance for earthquake loading for seismic zone 3, in accordance with the UBC.

B. Concrete: Embedded parts in the concrete structure and parts bearing on the concrete structure shall be designed such that stresses in concrete do not exceed the following values:

1. Bearing: 1,000 psi

2. Shear: 320 psi

3. Bond: 110 psi (to plain surface)

1.12 DELIVERY, STORAGE, AND HANDLING

A. The valve operatorand accessories shall be prepared for shipment in accordance with Section 15010, General Mechanical Requirements.

1.13 PROJECT/SITE CONDITIONS

A. Turbine shutoff valve and operator are to be located in an above grade concrete powerhouse. The hydraulic power unit and all TSV controls will be located in the new powerhouse. Control piping and cabling will be routed from the HPU to the TSV operator inside the powerhouse.

1.14 WARRANTY

A. All equipment shall be guaranteed in accordance with Section 15010, General Mechanical Requirements.

1.15 OPERATION AND MAINTENANCE

A. Equipment Supplier shall furnish Operation and Maintenance instructions in accordance with Section 15010 - General Mechanical Requirements. Instruction manual shall be specific to the equipment supplied for this project.

PART 2 - PRODUCTS

2.01 MATERIALS AND MECHANICAL EQUIPMENT

A. General requirements for materials and mechanical equipment shall comply with Section 15010, General Mechanical Requirements.

B. Material and workmanship requirements shall be according to Section 05000 – Materials and Workmanship unless specifically modified according to this section.

2.02 HYDRAULIC CYLINDER ASSEMBLY

A. The hydraulic cylinder assembly shall include a cylinder tube, cylinder heads, piston, piston rod, seals, accessories, and appurtenances to operate the turbine shutoff valve. The cylinder shall be designed for double action to apply a force to control the valve opening and closing rate. Relief valves shall be provided to limit pressure in the cylinder's lower and upper chamber in case the TSV jams or the pump fails to shut off when the valve is full open.

B. No valve shall be installed on the outside surface of the hydraulic cylinder except as noted.

C. Cylinder cushioning shall be contained within the cylinder body. A hose rupture valve shall be provided in a manifold mounted on the port of the lower chamber to prevent uncontrolled oil flow out of the cylinder in the event of a hose rupture.

D. The cylinder shall be located and mounted to suit Manufacturer's design. The cylinder support structures, including the cylinder trunnion and anchors, shall be adjustable to ensure proper connection and alignment between the valve and cylinder considering usual fabrication and erection tolerances.

2.03 CYLINDER

A. General: The hydraulic cylinder shall be of the double-acting, commercially available, Mill-type, designed and manufactured to meet the criteria specified. Cylinder body shall be manufactured from a single piece of material. The cylinder shall be straight and true and shall be of sufficient wall thickness to resist maximum operating pressure and bending forces. Each cylinder shall be equipped with screw-in quick connect test ports.

B. Cylinder Tube: Material for the hydraulic cylinder shall be a single piece of hot-rolled, seamless, normalized carbon steel. The cylinder bore shall be honed to a surface finish compatible with the seals being used so as to result in zero leakage past the seals but shall be 16 microinch or better. The assembled cylinder shall be of such straightness that the piston and rod move smoothly therein without any indication of binding or tight spots.

C. Cylinder Heads and Caps

1. Manufacture each cylinder head to attach to cylinder tube, and mount to cylinder support structure. Provide SAE O-ring seals for each cylinder head.

2. Manufacture each cylinder cap to attach to cylinder tube. Provide SAE O-ring seals for each cylinder cap. Rings, bearings, packing, packing rings, retaining rings, seals, wiper-scrapers, etc., shall be fabricated from the finest selected quality materials as recommended by the Equipment Supplier to provide zero leakage. The rod and gland of the cylinder shall be provided with a hydraulic cushion feature to reduce the impact at full-open and full-closed positions.

D. Piston: Manufacture the piston from forged or cast-steel. Accurately machine piston for wear bands, multi-lip chevron-type packing seal, O-rings and back-up rings, and locking ring. Piston shall be precision fitted to cylinder bores with threaded connections for rod and rod extensions. The design shall protect the piston rings from blow-out and over-squeeze. Securely fasten piston to rod using proven and reliable means, such as a cylinder piston pin. Rings, wear bands, retaining rings, seals, etc., shall be fabricated from the finest selected quality materials as recommended by the Contractor to provide zero leakage. Design of the piston shall permit easy replacement of seals and guide rings.

E. Piston Rod

1. Material for the piston rod shall be one of the following:
   a. Solid bar of corrosion-resistant steel, ASTM A 276, Type 316, with a hard-chrome plated outer surface. The “swept” outer surface of the rod shall be hard-chrome plated, shall be ground and polished to a

uniformly concentric finish with a rod finish of 10 rms or better and minimum finished radial thickness of 0.003 inch after final machining.

b. Solid carbon steel, ASTM A 572 with ceramic coating. The ceramic coating shall be a minimum of 0.008 inch thick and have surface finish of 12-14 rms. The ceramic coating shall have a surface hardness of 67 Rc minimum, impact resistance of 5-11 lb/ft, modulus of elasticity of 52,000-60,000 ksi, linear expansion coefficient of 4.0 x 10-6° F, and be capable of withstanding a fracture force of 41 ksi minimum. The ceramic coating shall demonstrate unique corrosion, scratch, and abrasion resistance. The corrosion resistance shall meet or exceed the requirements of ASTM B287-H1000 hour salt spray test.

2. Piston rod eye shall be in one piece and shall have a bushed hole for a pin connection to the valve. The eye shall be of rolled or forged steel, rigidly attached to the piston rod by threaded or bolted connection. Guide surfaces and shoulders shall be provided for proper alignment of the eye with the rod. Ceramic-coated piston rod shall have uncoated and unpainted carbon steel ends properly protected from corrosion by the use of CRES sleeves assembled with O-rings.

3. Connecting pins shall be of corrosion-resistant steel ASTM A 276, Type 316 or ASTM A 564, Type 630. The pin shall be positively secured against axial movement by either a shoulder on one end and a washer and retaining pin on the other end, or by a washer and retaining pin on both ends, or by bolted retaining plates. Use of snap-type retaining rings will not be permitted.

F. O-rings: Provide O-rings to seal fluid pressurized interfaces and joints between components of the cylinder assembly, where there is no relative movement.

G. Seals: Piston and piston rod seals shall be of the chevron-type packing seals, mechanically locked in place. Seals shall resist roll, turn, and extrusion.

H. Packing: Packing or static seals such as rings shall be provided between all connected parts where leak-tight joints are required, such as between cylinder tube and heads or between piston and piston rod.

I. Bosses, Drains, Vents, and Test Connections

1. Bosses: All necessary bosses shall be connected by welding.

2. Drains: All necessary drains shall be provided.

3. Air Bleed Valves: Cylinder shall be furnished with at least two air bleed valves for complete removal of trapped air. All air bleed valves shall be of stainless steel.

4. Test Connections. Cylinder shall be furnished with one test connection in each of the fluid ports for attaching a pressure gauge or transducer. Additional test connections shall be provided on the cylinder as required. All test connections shall be provided with corrosion-resistant steel type connectors.

J. Lifting Eyes: The cylinder shall be equipped with lifting eyes to facilitate ease of handling during transportation and installation.

K. Proximity Switches: Each cylinder shall be equipped with proximity switches, one at each end to stop the cylinder motion at the end positions of the valve. The proximity switches shall be suitable for operation in the control panel control circuit.

2.04 CYLINDER ASSEMBLY MOUNTING AND SUPPORT STRUCTURE

A. General: The cylinder assembly shall be provided with a trunnion mounting or other suitable means for connecting to the support structure and piston rod eye mounting to the valve lever arm. All embedded anchors, and embedded support plates shall be provided. The cylinder shall pivot freely as the operating lever rotates along its radial path.

B. Cylinder Trunnions

1. The cylinder trunnion shall connect the cylinder tube to the support structure which will transfer the loads to the concrete work in accordance with the arrangement shown on the Drawings or specified.

2. Bearings. Bearings for cylinder mountings shall include permanent self-lubricating bushings on spherical bearings on corrosion-resistant pins.

3. Cylinder mountings and support structures shall not interfere with servicing and inspecting the cylinder and valve equipment, shall prevent the rotation of the cylinder about its longitudinal axis.

C. Cylinder Support Structures

1. Cylinder support structures shall be designed to allow 3-direction, 6-way adjustment and leveling during erection.

2. The support structure shall be removable to allow removal of all parts of the operator or valve equipment. The location of all removable support structures shall be fixed by position lugs or dowels which shall position the removable components on the embedded or permanently installed parts.

2.05 PIPING

A. General

1. Pipe sections to be connected in the field shall be flanged using shop- or field-welded flanges or shall be designed for connection in the field by others with socket welded couplings. Pipe section shall not be designed for butt welding in the field. All connections for piping, valves, instruments, fittings, etc. shall be leak free.

2. The general arrangement of all piping shall be determined by the Equipment Supplier, subject to the review and approval of the Owner or Owner's Engineer.

3. The piping shall allow easy removal and reinstallation of the hydraulic cylinders and the power unit control module. For this purpose, all hydraulic lines connecting the hydraulic cylinder to the operator control modules shall be provided with flexible connections at the cylinder and if necessary at the power unit. Both ends of all flexible connections shall be connected with corrosion-resistant steel shut-off valves so that the piping, cylinder, and hydraulic power unit can be shut off when the connections are removed.

4. Manual vent valves shall be provided at all high points and wherever else required in the system for the complete removal of trapped air. The valves shall have threaded female ends and shall be of corrosion-resistant steel or bronze. The outlet ports of all vent valves shall be plugged with threaded bronze plugs.

5. Piping in the power unit shall be laid out such that it shall not obstruct access to, or removal of, hydraulic components for maintenance or inspection.

B. Pipe: Pipe shall be seamless stainless-steel conforming to ASME B36.19M and ASTM A 312, Grade TP304L. The piping weight class shall be Schedule 80. The pipe shall conform to the cleanliness requirements of ANSI B93.11.

C. Pipe Fittings

1. Pipe fittings shall be made of stainless-steel conforming to ASTM A 182, Grade F304L. The pressure class shall be 3000 psi.

2. Flanges shall be welding neck type conforming to ANSI B16.5 and made of stainless-steel conforming to ASTM A 182 with the grade suitable for the pipe to which it is attached.

3. Threaded fittings shall also conform to the above, but shall be used only where absolutely necessary for the application. Threaded fittings shall be of the straight thread, O-ring, SAE type connections.

D. Unions: Unions shall be the O-ring type, made of stainless steel with socket-welding ends. The Equipment Supplier may at his option substitute four bolt split flanges with Buna N O-rings for the unions.

E. Hydraulic Tubing: Tubing shall be seamless stainless steel tubing conforming to ASTM A 789. The wall thickness shall be selected to provide a safety factor of 6 based on the manufacturer's ratings for burst strength.

F. Tube Fittings: Tube fittings shall be made of stainless steel and be the flareless type with SAE straight threads and Buna N O-ring seals. The fittings shall conform with SAE J514.

G. Hose

1. Flexible connections shall allow reconnection of the hydraulic power unit or operating cylinder without realignment and shall also permit the necessary freedom of movement of the operating cylinder.

2. Flexible hydraulic hoses shall be SAE 100R12 4 spiral (medium wire) rubber hose, such as style CE rubber hose as manufactured by the Dayco Corporation, Dayton, OH 45401, or equal. Minimum burst pressure shall be 15,000 psi. Flexible hose shall be rated by the manufacturer for a working pressure not lower than 3000 psi with a factor of safety of 4. Rubber or synthetic rubber shall be selected for maximum compatibility with the hydraulic fluid specified for use in the system. Fittings shall be stainless steel and shall be specifically designed for use with the hose selected shall be equivalently rated and shall be as recommended by the hose manufacturer.

H. Test Connections: The power unit shall be furnished with test connections at appropriate locations for attaching a pressure gage or transducer.

I. Pipe Supports: Pipe supports such as pipe hangers, anchors, guides, clamps, etc. shall conform to the applicable requirements of ANSI B31.1, MSS SP-58, and MSS SP-69.

2.06 BOLTS, NUTS, AND WASHERS

A. Carbon Steel Bolts and Nuts: Carbon steel bolts and nuts shall conform to ASTM A 354, Grade BC, with ASTM A 194/A 194M, Grade 2H nuts. Structural bolted connections carrying primary loads shall be made with ASTM A 325 bolts.

B. Stainless Steel Bolts and Nuts: Stainless steel bolts and nuts shall conform to ASTM A 193/A 193M, Grade B7 or B16, with ASTM A 194/A 194M, Grade 8 nuts.

C. Flat Washers: Flat washers shall conform to ASTM F 844.

2.07 HYDRAULIC FLUID

A. The hydraulic fluid to be used during shop testing, to fill the cylinders before shipment, flush the system after installation, and to fill the complete hydraulic system shall be an all-weather type hydraulic oil which has a high viscosity index, low pour point, rust and oxidation inhibitors, and antifoam properties. The oil shall also be biodegradeable and non-toxic. Fresh hydraulic fluid shall be filtered through a 10 micron filter before it is added to the system. All oil shall be supplied by the Equipment Supplier, and shall be a common manufacturer, type, and grade for all valve hydraulic power system, governing system, and generator, **Shell Turbo T68**.

2.08 LOCAL CONTROL PANEL

A. General

1. The control panel assembly shall consist of a NEMA 13 unit-mounted panel with fixed sides and back with hinged front door. .

   All the field instrumentation signal from the TSV operator/ HPU shall be wired into the terminal blocks inside the control panel and eventually terminated into applicable I/O modules. Owner preferred controller is Allen Bradley Control Logix 5000 series. The HPU control panel does not need a separate controller of its own but rather the I/O modules in the local control panel shall communicate with the main controller in the Turbine and Generator Control Switchboard, details in section 16310. The allowed communication protocol is Ethernet I/P.

B. Enclosure

1. The control panel shall consist of a unit-mounted, formed, welded metal enclosure equipped with hinged front doors. The panel shall be fabricated from 14-gauge minimum sheet steel.

2. Steelwork shall be thoroughly cleaned after all welding, drilling, and punching has been completed. The cleaning process shall be immediately followed with a rust inhibiting priming coat. The mounting panels and the inside surface of the control panel shall be given a gloss white finish. The outside surface of the control panel shall be finished ANSI 61 light gray.

3. The control panel shall be equipped with a thermostatically controlled strip type space heater rated 115 volt, 1-phase, 60 Hz. The heater circuit shall be provided with a fused disconnect switch or circuit breaker.

C. Nameplate

1. Furnish nameplates for instruments, relays, control switches, push buttons, indicating lights, and other items where the circuit and function of the particular device cannot be otherwise readily determined.

2. Nameplates shall be made of white plastic cut through to a black background. The lettering shall be of a size and design such that it will be legible from reasonable angles of observation and from distances of at least 10 feet.

3. Nameplates shall be screw-mounted type.

D. Control Wiring

1. The control panel assembly shall be completely wired, and wires for connections to remote equipment shall be brought to terminal blocks. All wiring shall be neat and workmanlike, without splices and with a uniform arrangement of circuits. Wire bundles or single wires shall run in straight lines with 90-degree corners, where change of direction is required.

2. All control wire, inside the panel, shall be #18 AWG or larger. Wiring shall be UL type, SIS or MTW; flexible stranded copper, control wire.

3. Where possible wiring shall be run in plastic wire duct with covers. Where it is not possible to contain the wiring in the duct, the wiring shall be wrapped with plastic spiral binding. The plastic wire duct and spiral binding shall be as manufactured by the Panduit Company, Hoffman or approved equal.

4. Wire bundles crossing hinges shall be securely clamped to both the door and the panel, and run parallel to the hinge for at least half the door length to prevent chafing. No splicing shall be permitted in the wire duct or spiral wrapped wire bundles.

5. The wires connecting the various devices to each other and terminal blocks shall be labeled at both ends with identification marks. Wire labels shall be hot-stamped sleeve type.

6. Terminal blocks for control wiring shall be molded type, with barriers, rated not less than 300 volts, 25 amperes, suitable for conductors ranging between No. 22 and No. 14. White marking strips shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation placed on the marking strip with permanent marking fluid. Terminal blocks shall be Allen-Bradley Type 1492-F1, or approved equal.

7. Terminal blocks for control power terminations shall be fused type with fuse puller. Fused terminal blocks shall be Allen-Bradley Type 1492-CE6 with 1492-N12 fuse puller, or approved equal.

E. Pushbuttons

1. All pushbuttons shall be round, oiltight, heavy duty type units. Pushbuttons shall be Allen-Bradley Type 800T, or approved equal.

2. The pushbutton legend plates shall be engraved as shown on the Drawings.

F. Switches

1. All switches shall be round, oiltight, heavy duty type units. Switches shall be Allen-Bradley Type 800T, or approved equal.

2. The switch legend plates shall be engraved as described above.

G. Indicating Lights

1. Indicating light assemblies shall be round, oiltight, press-to-test, heavy duty type units. Each indicating light assembly shall contain a 120 volt ac, transformer type indicating light. The lenses shall be made of a material that will not be softened by the heat from the lamps. Lamps shall be replaceable from the front of the assembly. The indicating light assemblies shall be Allen-Bradley Type 800T, or approved equal.

H. Auxiliary Relays

1. Auxiliary control relays shall be vibration and shock resistant with dust covers and shall be rated for operation at 120 volts ac. Auxiliary relays shall be Potter & Brumfield Type KRP, or approved equal.

I. Power Supply

1. The power supply for the pressure transmitters shall be a computer grade, linear regulated unit. The power supply shall be rated for 120 volts ac input and 24 volts dc, 0.75 Amp output. The power supply shall be Elpac Power Systems SOLV15-24W, or approved equal.

J. Pressure Meters

1. The penstock pressure and differential pressure meters shall be a 3-1/2 digit readout units with readout proportional to a 4-20mAa dc input. The meters shall be equipped with zero and span adjustment capability. The display shall be 0.56-inch, 3-1/2 digit, 7-segment, red LED type. The indicating instruments shall be Red Lion Controls Model IMP, or “approved” equal.

K. Fuses

1. The control and indicating devices shall be fused with 13/32 x 1-1/2 inch duael-element type fuses. Fuses shall be Buss Fusetron Type FNM or equal. Each fuse shall be mounted in an Allen-Bradley Type 1492

2.09 SPARE PARTS

A. Equipment Supplier shall furnish the pricing for the following spare parts or material in the quantities listed below. In addition, recommended spare parts with unit pricing, typical lead time and recommended quantities shall also be listed.

Item	Quantity
Seals, scraper-wiper ring, and O-rings for one cyclinder	Two sets
Piston guide rings	Two sets
Piston chevron seals	Two
Fasteners (10% of lot for each type)	One set
Miscellaneous O rings, gaskets, seals, etc.	One set
Lamps for Indicating Lights	6 of each type
Control Relays	1 of each type
Hydraulic Oil (5 gal)	Two

2.10 SHOP ASSEMBLY AND TESTING

A. General

1. The valve operator shall be assembled and tested with the valve, and the hydraulic power unit shall be separately completely assembled in the shop and tested insofar as is possible using temporary piping and wiring to determine the correctness of fabrication and the matching of component parts to ensure acceptable operation after field installation. Shop tests shall be made in the presence of the Owner or Owner's Engineer, unless otherwise authorized in writing. After shop tests have been satisfactorily completed, the cylinder shall be shipped to the valve manufacturer's shop for final fit-up, assembly, and testing with the Turbine Shutoff Valve, refer to Section 11500 - Turbine Shutoff Valve.

2. In the shop, check and record main dimensions, fit-up dimensions and configurations, and clearances. Perform pressure, leakage, and operating tests and submit test results. At least 10 days prior to testing,

Equipment Supplier shall submit for review an outline of proposed test procedures and test plans to demonstrate fulfillment of the requirements of the Specifications.

3. Before disassembling and after installation of dowels and fitted bolts between subassemblies, all parts shall be clearly matchmarked.

B. Cleaning: Extreme care shall be taken during shop assembly to avoid inclusion of foreign materials into the equipment. The interior of the piping shall be cleaned with lint free cloths and flushed with oil at a minimum velocity of 15 fps which has passed through a 10 micron filter. The cleaning procedure shall be in accordance with ASTM D4174. The piping and valves shall be sealed with enough oil in the system to protect the metal surfaces.

C. Cylinder Tests

1. Each cylinder shall be fully shop assembled and inspected for proper fit-up of all components, correctness of dimensions, and ease of piston/rod movement.

2. For shop pressure and leakage testing, the cylinder shall be filled with the specified hydraulic fluid filtered to 10 microns, taking care to exclude all air. The tests shall be in accordance with ASME BPVC Section VIII, Division 1.

3. Shop pressure test: Equipment Supplier shall design suitable blocking equipment to permit hydrostatic pressure testing of each assembly without movement of the piston. The piston shall not be blocked against the blind end of the cylinder for the tests. Apply a hydrostatic test pressure of 1.5 times the working pressure for a minimum of 4 hours. Under this test no leakage will be allowed and none of the parts shall show any evidence of distress.

4. Shop leakage tests: After the pressure test has been satisfactorily completed, reduce the internal hydrostatic pressure to the design pressure and check piston seal leakage.
   a. Check piston leakage with the rod and piston fully retracted, and the pressure applied to the lower side of the piston, the upper end shall be observed for leakage past the piston.
   b. Repeat the leakage test by repeating the test with the rod and piston fully extended.
   c. Repeat the leakage test with the rod and piston at mid-stroke positions at 6 inch increments.
   d. Any leakage past the piston seals shall be cause for rejection.

5. Shop operating tests: After successful completion of the shop pressure and leakage tests and independent shop testing of the HPU connect the power unit, and operate the cylinder over the full range of travel. The

cylinder rod and piston shall then be extended and observed for smooth, even travel. Any operational problems or source of leakage to the outside of the cylinder will be cause for rejection.

2.11 PAINTING

A. All exposed exterior surfaces of assemblies and equipment except stainless steel, synthetic rubber, and plastic, shall be shop primed and coated as specified in Section 09900 Paints and Coatings unless the equipment is given a standard factory finish as allowed by other paragraphs of this specification. Insofar as is practicable, the complete coating system shall be applied to individual components and items before assembly to ensure complete coverage and maximum protection against corrosion. Equipment such as the pumps which have a factory-finished coating do not need to be recoated. Chips, scratches, and other damage to shop-applied painted surfaces shall be repainted in the field.

2.12 IDENTIFICATION

A. Equipment, piping, valves, and other components shall be labeled for identification in accordance with Section 15010 - General Mechanical Requirements.

PART 3 - EXECUTION

3.01 GENERAL

A. The layout of the hydraulic piping and electrical conduit shall be determined by the Equipment Supplier based on Owner or Owner's Engineer-approved final location of equipment.

3.02 INSTALLATION

A. Installation shall be performed as part of a separate contract by others. Installation of all components shall be in accordance with the Equipment Supplier's written instructions and/or drawings under the direction of the Service Department or manufacturer's representative. Necessary supports for interconnecting piping shall be provided under separate contract by installation contractor.

B. The installation shall be arranged to ensure that the cylinder and piping are permanently and completely full of hydraulic fluid under normal working conditions at all times, to avoid internal corrosion effects of moisture and other corrosive agents contained in air. The hydraulic arrangement shall also ensure, insofar as possible, that there is a positive fluid pressure within cylinders and piping, so that in the event of any lack of tightness, no air or water shall enter the hydraulic system.

C. Isolating shut-off valves shall be provided at all hose connections and other suitable locations in the hydraulic system to enable convenience of hose replacement and other parts without the need to drain all oil through the system.

3.03 CLEANING AND FLUSHING THE SYSTEM

A. Equipment Supplier shall submit a detailed cleaning and flushing the system procedure for approval as specified herein. Before installation of hydraulic power unit, cylinders and manifolds, all hydraulic field piping shall be flushed. Bypass loops of piping shall be installed in place of cylinders, manifolds, and the power unit.

B. Filling and Bleeding the System: Equipment Supplier shall provide a detailed procedure for filling and bleeding off any air that has become trapped in the piping system.

3.04 FIELD TESTS AND INSPECTIONS

A. Field Testing: The Engineer shall be given 2 weeks notice before any field testing is to be conducted. Any material, equipment, instruments, and personnel required for the tests shall be provided by the Contractor. Testing shall be conducted in the presence of the Engineer unless waived in writing and then a certified field test report shall be submitted as specified herein. Testing shall be done under the direction of the Service Department or manufacturer's representative.

B. Field Pressure Test: The piping system shall be hydrostatically tested to not less than 125 percent of the design working pressure. Any equipment that might be damaged by this pressure shall be isolated or removed to prevent damage. The test pressure shall be maintained for 4 hours. All welded, flanged, and threaded connections shall be carefully examined for leakage, and all lines shall be inspected for evidence of deflection caused by inadequate anchorage. No leakage or deflection will be allowed.

C. Field Operating Tests

1. See Section 15980 – HPU for field testing requirements.

3.05 SERVICE DEPARTMENT

A. The Equipment Supplier shall provide the services of an experienced and qualified Service Department or field service representative who is regularly employed by the hydraulic cylinder/power unit manufacturer to supervise the installation, start-up, adjustment and operation, and testing of the equipment provided. The Service Department shall furnish a signed statement certifying that the final installation and start-up of the hydraulic power system has been inspected, witnessed, and complies fully with the manufacturer's warranty requirements. The Service Department shall also instruct the Owner's operating staff members in the operation and maintenance requirements of the equipment. Refer to Section 15010 - General Mechanical Requirements, for additional requirements.

END OF SECTION

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SECTION 15010
GENERAL MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope: This Section provides the general requirements for mechanical equipment to be installed at the new penstock connection to the existing outlet pipe, and installed inside or adjacent to the new powerhouse.

B. Requirements of this section apply to the following equipment specification sections:

1. Section 11500 – Turbine Shutoff Valve
2. Section 11510 – TSV Operator
3. Section 15645 – Hydraulic Turbine
4. Section 15970 – Turbine Governor
5. Section 15980 – HPU
6. Section 16210 – Synchronous Generator
7. Section 16220 – Generator Termination Cabinet
8. Section 16230 – Generator Switchgear
9. Section 16250 – Iso Metering Cabinet
10. Section 16310 – Turbine and Generator Control Switchboard

1.02 CODES AND STANDARDS

A. Mechanical work shall comply with all national, state and local regulations.

B. Provide manufacturer's certification that materials meet or exceed minimum requirements as specifies.

1.03 SUBMITTALS

The following items shall be submitted to the Engineer:

A. Packing slips indicating all parts being delivered with each shipment according to part numbers as shown in assembly drawings.

a) Parts that are being delivered in assemblies or subassemblies should be itemized with the packing list for the assembly being delivered according to assembly drawings items numbers.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Exercise care in transporting and handling to avoid damage to materials.

B. Store materials on the site so as to prevent damage or theft.

C. Keep materials clean, dry, and free from deleterious conditions.

D. Do not store materials directly on the ground.

E. Repair or replace damaged material or equipment to satisfaction of Owner.

F. Protect electrical equipment, controls and insulation against moisture or water damage.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All equipment and material shall be designed for the service intended, shall be of rugged construction, of ample strength for all stresses which may occur during fabrication, transportation, erection and during continuous or intermittent operation, shall be adequately stayed, braced and anchored, and shall be installed in a neat and workmanlike manner.

B. Appearance and safety, as well as utility, shall be given consideration in the design of details.

C. Design, fabricate and assemble equipment and systems with new materials and in accordance with acceptable modern engineering and shop practices.

D. Manufacture individual parts to standard sizes and gauges so repair parts can be installed in the field. Make like parts of duplicate units interchangeable.

E. Welding materials shall conform to AWS D1.1

2.02 GUARDS

A. All exposed moving parts shall be provided with guards in accordance with the applicable safety requirements.

B. Guards shall be fabricated of flattened expanded metal screen, 3/4 inch No. 10, to provide visual inspection of moving parts without removal of the guard.

C. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts.

D. Openings shall be provided in the guard for access to the lubricating fittings.

2.03 NAMEPLATES

A. Equipment nameplates shall be engraved or stamped on stainless steel and fastened to the equipment in an accessible location with oval head stainless steel screws or drive pins.

2.04 EQUIPMENT MOUNTS, GROUTING, AND VIBRATION ISOLATION

A. Equipment mountings and grouting shall be as shown.

B. Where specified or noted in the Drawings, the equipment, including the base, shall be mounted on or suspended from vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the supporting structure.

2.05 WALL SLEEVES

A. Material: Standard weight steel.

B. Seep Collar: Steel, 1/4-inch thick extending at least 3 inches from the outside pipewall surface and welded to pipe with continuous watertight weld for all structures to be watertight.

2.06 FLOOR SLEEVES

A. Material: Standard weight steel.

B. Extend 1 inch above floor level in areas except finished areas.

C. Extend 1/4-inch above floor level in finished areas, but allow placement of escutcheons.

2.07 SEISMIC CONSIDERATIONS

A. Equipment Supplier shall submit detailed calculations for review by the Engineer which demonstrates that the anchor bolting for all equipment with an operating weight of 1,000 pounds or more (250 pounds in the case of vibration isolated equipment having seismic restraints) will not fail in shear or in tension.

B. Calculations shall be performed by an Engineer registered in the state in which the project is located.

C. Calculations shall include the following steps as a minimum:

1. Operating weight and centroid of the equipment. Operating weight and centroid for liquid-containing tanks shall be determined with the tank full to the high level and fluid specific gravity of fluid contained in the tank.

2. Shear and overturning forces at each anchorage due to a force equal to 0.5 times the operating weight of the equipment being applied at the centroid in each direction along the three principal orthogonal axes (use the values obtained in the dynamic analysis in the case of seismically restrained vibration isolated equipment).

3. Shear and tension forces which must be developed by the anchor bolts at each support to resist the forces calculated in the previous step.

4. Select anchor bolting details based on the maximum shear and tension forces calculated.

5. Details shall include, but not be limited to, number of bolts, material, diameter, total length and embedded length.

D. Vibration-isolated equipment shall be provided with snubbers capable of retaining the equipment in its designated locations without any material failure or deformation of the snubbers when exposed to a vertical or horizontal force at the contact surface equal to 100 percent of the operating weight of the equipment. Air gaps between retainer and equipment base shall not exceed 1/4-inch.

E. Types of anchorage shall be coordinated with the Installation Contractor so that anchorage may be installed at time of pouring of concrete. If calculations and anchorage details are not submitted prior to pouring of concrete, the Installation Contractor will become responsible for any strengthening of concrete elements because of superimposed seismic loading.

F. All piping, raceways, ductworks, accessories, appurtenances, etc., furnished with equipment shall be anchored to resist a lateral seismic force of 40 percent of its operating weight without excessive deflection. This force shall be considered acting at the center of gravity of the piece under consideration.

G. Piping with flexible connection and/or expansion joints shall be anchored such that the intended uses of these joints are maintained in the piping system.

2.08 TOOLS AND SPARE PARTS

A. All special tools required for the exclusive operation and maintenance of respective items of equipment shall be furnished with those items of equipment by the manufacturer.

B. This requirement includes special tools, instruments, accessories required for proper "in-plant" adjustment, maintenance, overhaul, and operations.

C. Tools shall be high-grade, smooth, forged, alloy tool steel.

D. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment, whether identified in the manufacturer's standard manual or not.

E. Spare parts shall be carefully packed in cartons, labeled with indelible markings, call out “Pine Flat Unit-4 Project” on the label, and shall be adequately treated for a long period of storage. All spare parts shall be put in cabinets provided by Installation Contractor. Location of cabinets to be approved by Engineer.

F. Complete ordering information including manufacturer's name and address, part ordering information including manufacturer, part number, part name, and equipment name and number(s) for which the part is to be used shall be supplied with the required spare parts.

G. Tools shall be mounted in location(s) directed by the Engineer.

H. Spare parts to be provided for certain equipment have been specified elsewhere in these Specifications. The Installation Contractor shall collect and store all spare parts as indicated above.

I. The Equipment Supplier shall furnish the Engineer with an inventory listing all spare parts, the equipment they are associated with, the name and address of the supplier, and the delivered cost of each item.

2.09 LUBRICANTS

A. The Equipment Supplier shall provide all mechanical equipment with a sufficient supply of Shell Turbo Oil T 68 lubricant for starting, testing, and initial 30-day operation period.

B. All lubricants shall be of types recommended by the applicable equipment manufacturer. The Installation Contractor, subject to the approval of the Equipment Supplier, shall limit lubricants to the least number or types required for normal maintenance of all equipment.

C. Not less than 90 days before the date scheduled for field testing of the equipment, the Equipment Supplier shall provide the Engineer with 3 copies of a listing indicating all lubricants required for each item of mechanical equipment.

D. Unless otherwise noted, all grease lubrication fittings shall be of an approved standard hydraulic type. Bushing shall be greaseless whenever possible.

2.10 LIFTING LUGS

A. Lifting lugs shall be provided for all equipment weighing 50 pounds or more.

2.11 VIBRATION

A. Except as specified elsewhere in these Specifications, all rotating, mechanical equipment shall not exhibit unfiltered peak-to-peak displacement readings in excess of the following amplitudes:

Speeds Range	Bearings - a)	Bearings - b)
900 rpm and below	3.0 mils	3.5 mils
901-1800 rpm	2.2 mils	3.0 mils
1801-3000 rpm	1.3 mils	2.5 mils
3001-4500 rpm	1.0 mils	2.0 mils
4501 and above	0.5 mils	1.6 mils

b) Measured on bearing housing in vertical axial and horizontal direction.

c) Relative shaft-to-casting motions in any plane for both rigid mounted and isolator mounted equipment.

B. Axial shaft vibration displacements (relative to casing) shall not exceed 50 percent of the maximum lateral shaft vibration displacements (relative to casing existing at any point along the shaft).

C. The above vibration responses are to include the range from 5.0 Hz to 5000 Hz and shall therefore encompass both low and high frequency responses of the subject equipment. The measurements shall be obtained with the equipment installed and operating at any capacity within the specified operating range. In addition to these maximum unfiltered readings, it is also stipulated that no narrow band spectral acceleration component, whether sub-rotational, higher harmonic or asynchronous multiple of running speed, shall exceed 40 percent of the synchronous displacement amplitude component without manufacturer's detailed verification of the origin and ultimate effect of said excitation.

2.12 PROTECTION AGAINST ELECTROLYSIS

A. Where dissimilar metals are used in conjunction with each other, suitable insulation shall be provided between adjoining surfaces so as to eliminate direct contact and any resultant electrolysis.

B. The insulation shall be bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials approved by the Engineer.

2.13 PAINTING

A. Manufactured Equipment:

1. Protect all steel and iron surfaces by suitable coatings applied in shop.

1. Protect for life of equipment surfaces which will be inaccessible after assembly.

2. Finish smooth, thoroughly clean and fill exposed surfaces, as necessary, to provide smooth uniform base for coating.

3. Coat surfaces to be painted after installation with one or more coats of primer to protect equipment until finish coats are applied.

4. Shop finish electric motors, speed reducers, starters, and other self-contained or enclosed components with oil-resistant enamel.

5. Apply rust preventive compound to all machined, polished and nonferrous surfaces which are not to be painted.

6. Furnish at least one quart of finish coat material with equipment for field touch-up.

B. Shop fabricated and/or Field Erected: As specified in Section 09900, Paints and Coatings.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Pipe, fittings, wiring and supports shall be provided to produce complete, operable systems with all elements properly interconnected as shown in schematic diagrams or to provide specified operations.

B. Equipment and materials shall be new and without imperfections and shall be erected in a neat and workmanlike manner; aligned, leveled, cleaned and adjusted for satisfactory operation; installed in accordance with the recommendations of the manufacturers and the best standard practices for this type of work so that connecting and disconnecting of piping and accessories can be readily made so that all parts are easily accessible for inspection, operation, maintenance and repair.

C. Cooperate with all trades in furnishing materials and information for correct location, in proper sequence, of all sleeves, bucks, inserts, foundations, wiring, etc.

D. Piping connections to equipment shall be made with unions or flanges to permit dismantling. Flanges and unions shall also be installed in the piping systems to permit disassembly consistent with good installation practice and as required for removal of connected equipment from place of installation.

E. Belt drives, flexible couplings and other exposed rotating or reciprocating parts shall be covered with approved safety covers. Covers shall be permanent type and easily removable.

F. Sleeves:

1. Sleeves through outside walls above grade shall be caulked with approved caulking.

2. Below grade shall be caulked with oakum and lead wool.

3. Pipe through walls and floors where exposed to view shall have floor or ceiling plate of size required, and shall be chromium plated, except where special escutcheons are required under plumbing fixtures.

4. Special sleeves through walls shall be installed as detailed.

3.02 COORDINATION OF WORK

A. Plan all work so that it proceeds with a minimum of interference with other trades.

B. Openings required in the construction for the installation of the work under this division, of these specifications shall be coordinated with work of all other trades.

3.03 INSULATING COUPLING

A. Furnish and install at all inter-connections between piping systems of dissimilar materials and at all connections of piping systems to equipment where piping and equipment are of dissimilar materials.

B. Couplings shall be specifically designed for the purpose of electrically isolating pipe lines from other piping systems or equipment.

3.04 WELDED INSTALLATION

A. Shop fabricated to maximum extent possible.

B. Use welders certified in accordance with the latest requirements of the American Welding Society "Standard Qualifications Procedures".

C. Repair protective coating and linings to a condition equivalent to the factory applied coating or lining.

3.05 PIPE OPENINGS

A. Openings in pipes and equipment shall be kept closed during the progress of the work.

3.06 VALVES AND VALVE DESIGNATION

A. Provide valves at each piece of equipment to provide for isolation of the equipment from its connected system.

B. Valves shall not be placed with stems below horizontal.

C. Provide chain wheel operators for all valves located higher than 7'-6" above finished floor.

3.07 ACCESS TO EQUIPMENT

A. All motors, valves, control devices, specialties, etc., shall be so located as to provide for easy access for operation, repair and maintenance.

B. Concealed access doors shall be provided.

3.08 LUBRICATION

A. Provide lubrication for the operation of all equipment until acceptance.

B. Provide with a chart listing each piece of equipment, the proper type of oil or grease required and recommended frequency of lubrication.

C. Installation Contractor shall be required to run in all bearings and, after they are run in, shall drain and flush bearings and refill with a new oil charge.

D. Oil lubrication fittings shall be located within reach from the operating surface. In order to meet these requirements with equipment as furnished, minor deviation from the Drawings may be made as favorably reviewed by the Owner.

END OF SECTION

SECTION 15060
PIPING AND APPURTENANCES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Section provides the general requirements for supply of the cooling water, lubricating oil, and hydraulic oil systems for the new turbine-generator.

B. Piping systems that can be reasonably assembled in the shop prior to shipment shall be so assembled and tested as described herein.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1. American National Standards Institute (ANSI)

   ANSI B2.1 Unified Inch Screw Threads

   ANSI B16 Cast Iron Pipe Flanges and Flanged Fittings

   ANSI B36.10M Welded and Seamless Wrought Steel Pipe

   ANSI B93

2. American Society of Mechanical Engineers (ASME)

   ASMI B31.1 Power Piping

3. American Society for Testing and Materials (ASTM)

   ASTM A 53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

   ASTM A 106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

   ASTM A 183 Standard Specification for Carbon Steel Track Bolts and Nuts

   ASTM A 234 Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

4. American Water Works Association (AWWA)

C200	Steel Pipe
C207	Steel Pipe Flanges for Waterworks Service - Sized 4 in. Through 144 in. (100mm Through 3600mm)
C208	Dimensions for Fabricated Steel Water Pipe Fittings
C219	Bolted, Sleeve-Type Couplings for Plain-End Pipe
M11	Steel Pipe – A Guide for Design and Installation

5. American Welding Society (AWS)

1.03 SUBMITTALS

A. Submittals shall conform to the requirements of Section 01300.

B. Submit material lists, material certificates, catalog data, product specifications and descriptive literature, and performance data for items provided.

C. Shop Drawings.

1. Submit piping arrangement drawings of piping systems showing layouts and details.
2. Submit schematics of piping systems, including descriptions of component functions and legends.

D. Quality Assurance/Control Submittals.

1. Field testing procedures, including cleaning, flushing, pressure testing, and operational testing.
2. Field Test Report.
3. Closeout submittals.
4. Operation and maintenance manuals in accordance with Section 01300.

1.04 DESCRIPTION OF WORK

A. Furnish all pipe, valves, fittings, and appurtenances including, but not limited:

1. Generator bearing cooling water system.
2. Turbine guide bearing cooling water system.
3. Generator air cooling water system.
4. Turbine shaft runner and hub seal water system.

B. Provide the following system specialties:

1. Pressure and flow switches.
2. Flow and temperature indicators.
3. Automatic self-cleaning strainer system.

C. Provide flow switches and flow indicators for each branch line.

D. Provide temperature transmitter on generator cooler discharge.

E. Provide all appurtenances required to complete the piping systems including but not limited to unions, couplings, gaskets, joint compound, pipe hangers, pipe supports pressure gauges, and flange and anchor bolting.

F. Field installation, clean, inspect and test all complete piping systems (by Others).

PART 2 - PRODUCTS

2.01 STEEL PIPE

A. Steel Pipe: ASTM A53, Type E or S, Grade B, or ASTM A106, Grade B. Pipe shall be suitable weight in accordance with ANSI B36.10M, unless otherwise shown or specified, and shall meet dimensional requirements of ASTM A53 for diameters up to 26 inches and ANSI B36.10M for diameters larger than 26 inches.

2.02 FLANGES

A. Conform to the material and dimensional requirements of AWWA C207. Class E flanges shall be used for design pressures up to 150 psi. Class F flanges shall be used for design pressures up to 300 psi. Provide weld neck flanges where flanges are shown or required at wrought fittings.

B. Alternatively, flanges may conform to ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800, and ANSI B16.5, Pipe Flanges and Flanged Fittings.

2.03 JOINTS

A. Provide butt-welded, flanged, and/or threaded joints for pipe and fittings.

B. Provide plain-end pipe for flexible pipe sleeve couplings.

C. Where piping connects to wall pipes, meters, valves, or other equipment, match the pipe ends to the ends of the wall pipes, meters, valves, or equipment.

D. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water-impervious isolation barrier.

2.04 FITTINGS

A. Fabricated steel fittings shall be in accordance with AWWA C208. Reinforcement of fittings shall be in accordance with AWWA M11.

2.05 WELDING FITTINGS

A. Provide butt-welded wrought carbon steel fittings conforming to ASTM A234, Grade WPB. Minimum thickness shall equal the thickest matching pipe.

2.06 GATE VALVE

A. 2 in. and Under: Bronze body, bronze trim, rising stem, handwheel, inside screw, double wedge or disc, threaded ends.

B. Over 2 in.: Iron body, bronze trim, rising stem, handwheel, OSY, double sedge, flanged ends.

2.07 BALL VALVE

A. 2 in. and Under: Stainless steel body, stainless steel ball, Teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends.

B. Over 2 in.: Cast steel body, chrome plated steel ball, Teflon seat and stuffing box seals, lever handle or gear drive handwheel for sizes 10 in. and over, flanged ends.

2.08 SWING CHECK VALVES

A. 2 in. and Under: Bronze body, bronze swing disc, bronze trim, threaded ends.

B. Over 2 in.: Iron body, bronze trim, bronze swing disc, renewable disc and seat, flanged ends.

2.09 PRESSURE GAUGES

A. Manufacturer: Ashcroft, Model: No. 1010, or equal.

B. Type: Pressure gauge for water or air service.

C. Construction:

1. 2-1/2-in. diameter dial and black Alumalife case. Dial engraved with the units in which the gauge is calibrated. Select scales so that the normal operating pressure falls between 50% and 80% of full scale.
2. Pressure range: Dial engraved with the units in which the gauge is calibrated.
3. Accuracy: ½ of 1% of full scale.

D. Isolate gauges by an elastomeric diaphragm isolator. Factory-charge the pressure gauge diaphragm isolation unit with glycerine, or other liquid recommended by the manufacturer for the service intended. Diaphragm material: as recommended by the manufacturer for the service intended.

E. Provide pulsation dampener, pin-type, on gauges not provided with a diaphragm isolator.

F. Pressure Gauge Locations Schedule:

1. Upstream and downstream of automatic strainer.
2. Adjacent each flow indicator.

2.10 INSTRUMENTS

A. Pressure Transmitters.

1. Pressure transmitters shall have pressure ranges as required for the application. Isolating diaphragms shall be 316 stainless steel and fill fluid shall be silicone. Process flanges and adapters shall be 316 stainless steel. Transmitter outputs shall be 4-20 mA dc with an accuracy of +/- 0.25% of calibrated span. Transmitters shall be furnished with local zero and span adjustment. Transmitters shall be loop powered with a 24 V dc power supply. Connections to the pressure piping shall be SAE straight thread, O-ring type. Transmitters shall be Rosemount 1151GP Series, or equal.

B. Position Transmitters.

1. Position transmitters shall be as specified elsewhere in these specifications.

2.11 SWITCHES

A. Limit Switches

1. Mechanical limit switches shall be heavy-duty oil tight NEMA Type 13 Allen-Bradley Bulletin 802 or equal. Electrical contact rating shall be 130 VDC.

B. Pressure Switches

1. Pressure switches shall be heavy-duty oil tight NEMA Type 13 Allen-Bradley Bulletin 836 or equal. Electrical contact rating shall be 130 VDC.

C. Temperature Switches

1. Temperature switches shall be heavy-duty oil tight NEMA Type 13 Allen-Bradley Bulletin 836 or equal. Electrical contact rating shall be 130 VDC.

D. Flow Monitor/Switch

1. Vane style flow monitors shall be located in the cooling water return lines. The flow monitor body shall be brass with stainless steel internal moving parts and Buna N seals. The flow monitor shall be furnished with a local flow indicating meter and adjustable flow switches. Two flow switches shall be furnished with electrically independent sets of contacts one each for low flow alarm and low flow shutdown. Contacts shall be rated for 130 volt dc operation. The flow monitors shall be Universal Flow Monitors, Inc. Series SN/MN, or equal.

2.12 FLOW INDICATORS

A. Flow indicators shall provide sight viewing to show flow/no-flow of piped fluids with an internal ball for flow indication. The indicators shall be of the size and pressure rating of adjacent piping. Corrosion resistant materials for the applicable fluid shall be used. The indicators shall be as supplied by Ametek Division of Shutte and Koerting, or equal.

2.13 AUTOMATIC SELF CLEANING STRAINER SYSTEM

A. General.

1. Provide strainer for cooling water system in main header.

B. Strainer.

1. The strainer body shall be of cast iron construction, housing a rotating tapered cast iron drum attached to a steel shaft, which is supported on bearings. The bearings and shaft shall be free from contact with the fluid stream. The drum shall be drilled and tapped to receive replaceable straining media in the form of slotted delrin cones with 0.075 inch slots. The drum must be capable of withstanding a 50 psi pressure drop without damage to the drum.
2. No mechanical fasteners, nuts, bolts, spring, or clips subject to failure, loosening due to vibration, etc., will be allowed on the "clean" water side of the strainer. For removal of backwash effluent, a vertical backwash slot with a sharp edge shall be cast integral within the strainer body. The edges of the backwash slot shall provide a positive shearing action to any debris caught in the strainer element pockets, which will not pass into the backwash slot as the rotor moves past the slot. No rubber or synthetic materials are to be used in the backwash section. Any scraper mechanisms, backwash rotors, or other devices that would be subject to either wear or are placed in "nonstrained" water are specifically excluded. Backwash shall be automatic with operation and controls as described below.
3. The strainer shall be sized to handle all cooling, lubricating, and service water for Unit 4, plus 20%, at the existing working pressure. The pressure drop across clean media shall not exceed 1.5 psi.
4. An inspection opening shall be provided to permit visual inspection or changing of straining media. Media must be capable of being changed without removing the drum or requiring disassembly of the strainer. One hundred percent replacement media shall be provided with the strainer.
5. A drain opening shall be provided in the lower part of the strainer body to permit drainage without removing drum.
6. Each square inch of straining media must be capable of being completely backwashed a minimum of 9 times per minute.
7. The strainer shall be driven by a 115 volt, single phase, 60 Hz totally enclosed motor with a gear reducer.

C. Automatic Backwash Control.

1. The automatic backwash controls shall consist of an electrically actuated shut-off ball valve.
2. The valve actuator shall be actuated on a timed basis with a pressure differential switch override. The timer shall be of the ON-OFF repeat cycle type having a 30 minute dial with a minimum setting of 30 seconds adjustable, case mounted NEMA 12. The pressure differential switch shall be mounted on the strainer with necessary tubing, petcocks, and fittings and shall override the timer to open the backwash valve at a present pressure differential, normally set at 5 psid.
3. A NEMA 12 control panel shall be provided for local wall mounting. The panel shall consist of the following:
   a. Two indicating lights marked “Valve Open” – “Valve Closed”
   b. One three-position selector switch marked “Manual-Off-Automatic”

c. One two-position selector switch marked “Open–Closed”
d. One contact for external alarm

D. When the three-position selector switch is placed in the automatic mode, the timer and pressure differential switch shall operate the ball valve. When the three-position selector switch is placed in the manual mode, the valve shall be operated by the two-position selector switch, marked “Open-Close”. All of the above controls shall operate on 120 volt, single phase, 60 Hertz.Drain Lines

1. Provide drain lines for backwash and drainage. Route drain lines to location “approved” by the Engineer/ Owner.

2.14 COUPLINGS

A. Provide sleeve couplings, dismantling joints, and flange couplings as required to install piping and components.

B. Coupling design shall conform to AWWA C219.

C. Manufacturer: Viking-Johnson or equal.

2.15 FLEXIBLE HOSE

A. All flexible pressure hose shall be multi-spiral design. The inner tube shall be seamless and shall be wound with alternate layers of spiral reinforcement in opposite directions, each separated by a layer of suitable synthetic rubber. The outer cover shall be resistant to abrasion and weathering in the environment of the installation.

B. Flexible hose end fittings shall be stainless steel and factory swaged.

2.16 FABRICATION

A. Piping may be either field or shop fabrication. All fabrications of pipe shall conform to the requirements of ASME B31.1 and other applicable codes.

B. Flange bolt holes shall straddle the normal vertical centerline unless otherwise indicated on the Drawings or mating equipment.

C. All shop fabricated piping shall be prepared for shipment in a manner that ensures delivery to destination in good condition. Particular attention shall be given to the protection of flange faces and threads. Flange faces shall have a rust preventative coating and plywood cover.

D. Pipe support, guide and anchor attachments and any other attachments which weld directly to the pipe wall shall be of a material that is compatible to the pipe wall material; the weld electrode used shall be compatible to the attachment and pipe wall material.

E. Pipe supports shall be furnished by the equipment supplier as required by ANSI standards.

2.17 PIPE JOINT COMPOUND

A. Use American National Taper pipe threads on all threaded joints. Apply joint compound to the male threads only. Pipe Joint compound shall be Teflon thread sealant Bakerseal by Radiator Specialty Company, La-Co SlicTite by Lake Chemical Company, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION (BY OTHERS)

A. Installation of piping systems furnished under the Equipment Supply contract will be by Others.

B. Provide unions and insulating unions at the following locations:

1. Valves.
2. Strainers.
3. Flow and pressure measuring elements.
4. Elsewhere as required to facilitate the following:
    a. Removal of equipment.
    b. Servicing of piping systems.
5. Insulating unions between dissimilar piping materials.

C. Shop assemble piping as much as practicable:

1. Fabricate pipe sections in manageable units.
2. Use fitting jigs to ensure proper alignment of joints.

D. Provide temporary plugs or bulkheads for the closure of all open ends of the piping prior to shipment to the project site.

E. Provide nonconducting dielectric connections wherever jointing dissimilar metals.

3.02 AUTOMATIC STRAINER

A. The strainer shall be installed at the inlet to the turbine-generator cooling water system per the manufacturer's installation instructions.

B. The strainer shall be hydrostatically tested prior to initial operation. No leaks will be acceptable.

C. All manual and automatic functions shall be tested to ensure that all of the mechanical and control systems are fully operational.

3.03 INSTRUMENTS AND CONTROLS

A. Locate units where they are easily visible and accessible.

B. Preset pressure and flow switches, and other control devices for proper operation.

3.04 ERECTION TOLERANCES

A. Establish invert elevations, slopes for drainage to 1/8 in./ft. minimum. Maintain gradients.

B. Slope water piping and arrange to drain at low points.

3.05 PAINTING

A. For painting of piping and valves refer to Section 09900.

3.06 HYDROSTATIC TESTING

A. Piping systems partially or fully assembled in the shop shall be hydrostatically tested.

B. Hydrostatic testing of all pipe systems covered by this Section will be performed on the installed system, by Others.

END OF SECTION

SECTION 15645
HYDRAULIC TURBINE

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section covers the design for the horizontal Francis turbine and defines the contract item Turbine. The contract item Turbine includes designing, manufacturing, factory testing, delivering, and storing the turbine.

B. The preliminary design drawings show an arrangement with one horizontal Francis turbine. The manufacturer shall be responsible for selection and design of the unit and appurtenant equipment.

C. The specifications herein address Francis turbines.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. American Society of Mechanical Engineers (ASME)

ASME PTC 18 Hydraulic Turbines - Performance Test Codes Boiler and Pressure Vessel Code and Interpretations

ASME B30.20 Below-the-Hook Lifting Devices

ASME/ BPVC-1 Rules for Construction of Pressure Vessels

B. American Society for Testing and Materials (ASTM)

ASTM A27 Standard Specification for Steel Castings, Carbon, for General Application

ASTM A148 Standard Specification for Steel Castings, High Strength, for Structural Purposes

ASTM A182 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

ASTM A 240 Heat-Resisting Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels

ASTM A516 Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

ASTM A743 Castings, Iron-Chromium, Iron-Chromium Nickel, Corrosion Resistant, for General Application

ASTM A688 Standard Specification for Seamless and Welded Austenitic Stainless Steel Feedwater Heater Tubes

ASTM B271 Standard Specification for Copper-Base Alloy Centrifugal Castings

C. Centre for Energy Advancement through Technological Innovation (CEATI) International:

T122700-0381 Hydroelectric Turbine-Generator Units Guide for Erection Tolerances and Shaft System Alignment, Part I: Definitions, Dated June 2015

D. Cahier Des Charges Specification for Inspection of Steel Castings for Hydraulic Machines (CCH 70)

E. International Electrotechnical Commission (IEC)

IEC 60193 International Code for Model Acceptance Tests for Hydraulic Turbines

IEC 60041 Field Acceptance Tests to Determine the Hydraulic Performance of Hydraulic Turbines, Storage Pumps, and Pump-Turbines

F. International Standard (ISO)

ISO 1940 PT1 Mechanical Vibration -- Balance Quality Requirements of Rigid Rotors - Part 1: Determination of Permissible Residual Unbalanced First Edition

G. ISO 4386 Plain Bearings--Metallic multilayer Plain Bearings American National Standards Institute (ANSI)

H. American Society of Nondestructive Testing (ASNT) SNT-TC-1A Recommended Practice

1.03 SUBMITTALS

A. All Submittals shall be in accordance with Section 01300.

B. Within forty five (45) days of receiving the Notice to Proceed, a report shall be submitted demonstrating the basis for the turbine hydraulic performance guarantees based on prototype or model tests. Turbine performance curves showing horsepower output, efficiency, and flow versus gate opening covering the entire operating head range, and at the speed corresponding to the prototype turbine speed.

C. Drawings

1. A minimum of ninety (90) days before proceeding with manufacture of the equipment or components, the Supplier shall submit general assembly drawings, subassembly drawings, detail drawings, calculations, engineering data, catalog sheets, and similar engineering documents required to demonstrate fully that all parts will conform to the provisions and intent of this Section, and to the requirements related to installation, operation, and maintenance. Drawings shall

show all necessary dimensions and fabrication details, including the type and grade of materials, details of welded and bolted joint connections, tolerances on fits and clearances, surface finish, nondestructive examinations, and all field joints.

2. General arrangement drawing of combined turbine-generator assembly.
3. General arrangement drawing of the turbine and appurtenances.
4. General arrangement drawings of governor oil piping and miscellaneous piping in the turbine pit.
5. Cross sectional drawing of combined turbine-generator assembly.
6. Cross sectional drawing of turbine and miscellaneous details, showing the internal arrangement of parts, working clearances and other details.
7. Detailed drawings of miscellaneous equipment, such as the lifting and handling equipment, runner templates, and equipment mounting frames, as required.
8. Fabrication and machining drawings with Bill of Materials.
9. Concrete outline drawings.
10. P&IDs.
11. Hydraulic, cooling water and electrical schematics.
12. Electrical wiring diagrams and interconnects for turbine, instrumentation and auxiliaries.
13. Lifting and handling diagram that details all lifting equipment including capacities, weights and any restrictions, fixtures, pick points on equipment, and plan and procedures for handling equipment.
14. Other drawings specified herein or may be needed to clarify or document the design.
15. All drawings marked with equipment tag numbers shall be in accordance with a numbering system approved by the Owner.

D. Engineering Data

1. Calculations, engineering data, analyses of the following:
    a. Turbine basis of design.
    b. Finite Element Analysis of Turbine Components.
    c. Turbine runner stress and fatigue analyses
    d. Turbine shaft stress and fatigue analysis.
    e. Turbine/generator shafting system – critical speed analysis.
    f. Vibration analysis (amplitudes and frequencies, including checks of resonance for turbine and generator components and water passages.
    g. Pressure transients and speed rise analysis for the entire system including, but not limited to, the intake, bifurcation, penstocks, and turbine water passages
    h. Hydraulic thrust analysis over full operating range.
    i. Runner-shaft connection analysis.
    j. Air admission analysis.
2. Datasheets showing capacities, ratings, weights, and performance data.
3. Load diagrams showing loads transferred from the turbine-generator assembly to the supporting structures.

E. Procedures and Instructions

At least 90 days prior to the earliest physical activity related to the below listed items, submit the following;

1. Manufacturing process plan (MPP).
2. Inspection and test plan (ITP) – for shop and field work.
3. Welding procedures specifications (WPS).
4. Post weld heat treatment and stress relief procedures.
5. Nondestructive Examination (NDE) procedures and specifications.
6. Shop assembly and factory test procedures with check sheets.
7. Installation drawings, procedures, and check sheets.
8. Field testing and commissioning procedures with check sheets.
9. Complete O&M manual (electronic and hardcopy) in accordance with Section 01300.
10. Runner blade profile template instructions and diagrams, and not less than the number of templates and location of templates specified in IEC 60193.
11. Other procedures or quality documents specified in Section 01400 or in this Section that are needed to clarify or document the work.

F. Reports

1. Factory test and Quality Control reports.
2. Field test report.

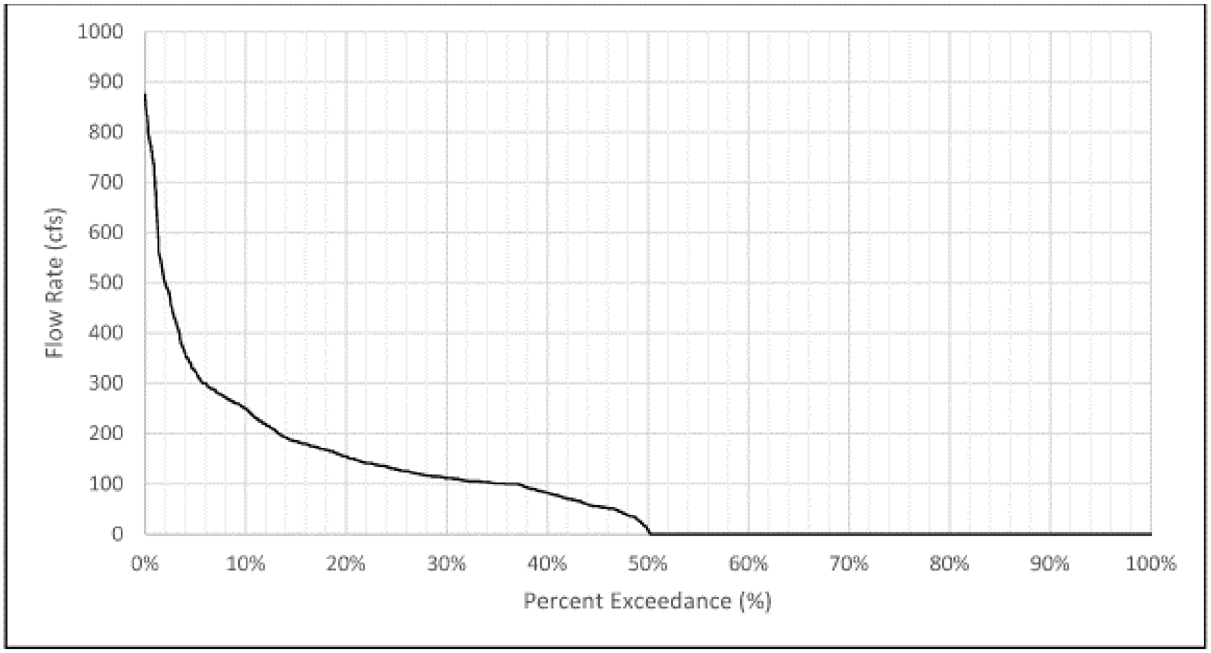
G. Shipping and Delivery Plan including a shipping list which describes what is to be shipped, when it is to be shipped, what is to be shipped in each container or vehicle, protection details, mode of transportation, long term/ short term storage requirements, MSDS and other material and safety information, and contact information for transportation company. See Section 01010 for additional requirements.

1.04 DESIGN PARAMETERS

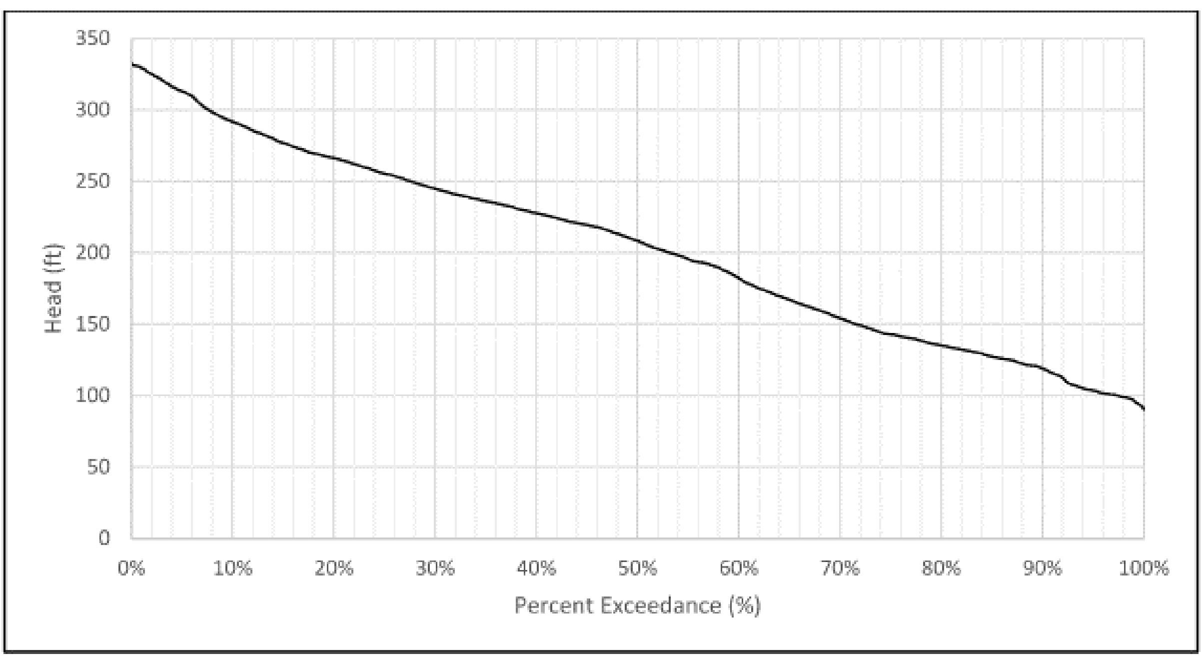
The new hydro turbine unit at Pine Flat (Unit-4) will be tied into the existing 600 CFS rated Bypass-1 pipeline, which is tapped commonly into existing Unit-1 and Unit-2 Penstocks. It shall be noted that there is another bypass system, Bypass-2 tapped into existing Unit-3 Penstock which is 300 CFS rated. The Bypass system at Pine Flat was installed in the early 2000's and was installed primarily to manage environmental aspects of the downstream Kings River. Minimum flow requirement through Pine Flat into the downstream Kings river is 100CFS which is mostly maintained through the Bypass system discharges, when the existing three units are not generating. A small creek by the name of Mill Creek runs downstream of Pine Flat Power Plant which also contributes to the downstream Kings River. Typically, the creek contributes to the flow only during the rainy season, that is typically between December through March. For the minimum downstream flow of 100 CFS requirement, the owner is allowed to add Mill Creek's contribution. Regardless of the flow through Mill Creek, Pine Flat is still required to discharge a flow of 50CFS minimum, either through the existing units, bypass system or the dam spill system.

The owner expects to run Unit-4 during the period when the other existing three large hydro units are not generating due to low head and low irrigation flow demands.

A. The new turbine unit will be installed as a new branch off of the Pine Flat Dam Bypass. The Pine Flat Bypass Flow and Head Exceedance Curves are provided in the figures below. Preliminary design drawings set the horizontal Francis unit centerline at 612 feet elevation with the centerline of the discharge at 618.65 feet elevation discharging to free air.



Pine Flat Bypass Flow Exceedance Curve



Pine Flat Bypass Head Exceedance Curve.

B. Principal design parameters for the turbine in terms of head and flow conditions are as follows.

Parameter	Description
Unit Type	Horizontal Francis
Design Discharge†	250 cfs
Maximum Operating Discharge	300 cfs
Minimum Operating Discharge	60 cfs
Design Head†	195 ft
Maximum Operating Head	260 ft
Minimum Operating Head	100 ft
Maximum Shaft Power	According to supplier design

†Design conditions are recommended to serve for initial equipment sizing purposes, bidders may adjust the design condition of the unit to best capture the hydraulic conditions of the site.

1. Net head of the prototype turbine shall be measured at high and low pressure piezometer taps at cross-sections located at the turbine inlet and draft tube outlet. The water passages cross-sections shall be fully homologous with the model. Net head shall be defined according to IEC 60041.

C. Unit Centerline: Preliminary layout drawings of the powerhouse have assumed a runner centerline of EL. 612 feet.

D. Rated Speed: 400 rpm and consistent with cavitation free operation when operating at minimum tailwater level. The Supplier shall state any exceptions if a different speed is proposed as an Alternate Bid. As noted elsewhere, the Bidding Documents have been set up to allow turbine suppliers to offer a unit speed different than that specified (400 rpm) for the Base Proposal, so as to compare the cost of the units, together with their relative merits in terms of performance, efficiency, and other pertinent factors prior to award.

E. Wicket Gate Timing: Selected by turbine supplier based on maximum allowable pressure rise of 20% during transient events.

F. Location: Enclosed powerhouse as shown on preliminary powerhouse drawings.

G. Seismic conditions: See Section 01010.

1.05 DESIGN CRITERIA

A. The Basis of Design for determining performance guarantees shall be a hydraulic model previously tested in a hydraulic laboratory in accordance with IEC 60193 and subsequently field tested to validate the hydraulic design. The prototype turbine efficiencies and other guarantees shall be based directly on the performance measured on the model. Step-up in turbine efficiency shall be in accordance with

IEC 60041. In lieu of a hydraulic model being used as a basis for the hydraulic design, the Owner may consider hydraulic designs based on turbines installed and field tested in accordance with IEC 60041.

B. The turbine shall have a minimum service life of 50 yrs. before major overhaul or major repairs are required.

C. Supplier shall be responsible for the turbine design based on conservative and best engineering practices. Supplier shall prepare detailed calculations and analyses to demonstrate the adequacy of the turbine design.

D. Design and selection of materials shall include due consideration to ensure against fatigue damage, fretting, excessive deflections, vibration, wear, and other factors which may impair or reduce the functionality, durability, and service life of the turbine.

E. Stress Analyses

1. Finite element analyses (FEA) shall be carried out for more complex components or complex loadings. Traditional analytical stress calculations may be used for components with simple geometries that are subject to well-defined loads.

2. Working stresses, bearing pressure, and other design criteria such as limits of deflection, torsional distortion, and alternating stresses shall be determined foremost on the basis of producing a functionally reliable trouble-free and long-life design. The Supplier shall be responsible for an adequate design based on factors proven in practice and shall use lower working stresses wherever deemed necessary or desirable. Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock. The design of the equipment shall include an allowance for earthquake loading in accordance with the ASCE 7-10.

3. Stress concentration factors shall be used where applicable. Reduction of allowable stresses to compensate for repeated and high cycles of loading is not required.

4. The following are references made to ASME Boiler and Pressure Vessel Code, Section VIII, Division 2. It shall be understood that these references apply to version 2007 or more current versions of the Code. It should also be noted that while the general principles of the ASME Code are followed, it is recognized that the Code was developed strictly for pressure vessels and some criteria had to be modified to be applicable for Spherical Turbine Shutoff Valves.

5. The allowable equivalent stresses in this Section are based on the maximum distortion energy (i.e., von Mises) failure theory.

6. Terminology

   SU = Ultimate tensile strength of material

   SY = Yield tensile strength of material

Primary stresses

Pm = General membrane stress

PL = Local membrane stress

Pb = Bending and torsion

Secondary stress

Q = Secondary membrane stress

Peak stress

F = Peak stress

S = Basic allowable equivalent stress

Sa = Amplitude of stress variation for fatigue calculations. The amplitudes shall be calculated using the stipulations of ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, Part 5.

7. Allowable Stresses

a. The basic allowable equivalent stress values S shall be defined as follows:

S = lesser of A x SY or B x SU

Where	A = 0.333 B = 0.21	for Normal Operating Conditions
	A = 0.444 B = 0.28	for Overload Conditions
	A = 0.500 B = 0.31	for Extreme Overload Conditions

and the following limitations for the various stress categories shall be met:

$Pm \le S$

$PL \le 1.5 \times S$

$PL + Pb \le 1.5 \times S$

$PL + Pb + Q \le 2 \times S$

$PL + Pb + Q + F \le 2 \times S$ for static loading and stresses

$PL + Pb + Q + F \le Sa$ for fatigue loading and stresses

b. Buckling

Buckling analysis of slender structural members shall be performed as part of the FEA, or in case of manual calculations according to ANSI/AISC 360, Specification for Structural Steel Buildings, latest revision allowable stress design (ASD) method. The minimum factor of safety against buckling for normal loading conditions associated with Pm and PL + Pb stresses shall be 1.67 and it shall be 1.5 for PL + Pb + Q normal loading conditions. For overload and extreme overload conditions the minimum factors of safety can be reduced by ten percent.

8. The root diameter of the threads shall be used to calculate the radius of gyration and area for the threaded parts.
9. The piston rod slenderness ratio L/r shall not exceed 60.
10. For components which are subject to cyclical stresses, a Soderberg Diagram with a factor of safety of three shall be used to determine the allowable stress combinations.
11. Where prestressing of bolts or studs is required, the minimum prestress shall result in not less than 125 percent of the force required to prevent separation of the joints; the stress shall not exceed 50 percent of the minimum yield strength of the material.

F. Fatigue Analyses

1. Fatigue analyses shall be carried out for components where stress concentrations and/or cyclical loadings exist.
2. Fatigue calculations shall be in accordance with the requirements of ASME Section VIII, Division 2, Part 5, Design by Analysis Requirements. The fatigue S-N curves used for the calculations shall be the appropriate smooth bar and welded joint design fatigue curves included ASME Section VIII, Division 2, Annex 3.F, Design Fatigue Curves. The stress amplitude of the fatigue curves shall be reduced to sixty percent (60%) for mechanical components and the full amplitude shall be used for structural components.
3. Design Criteria for Fatigue Analyses: The following conditions shall be considered as minimum design criteria for fatigue calculations:
    a. Minimum Fatigue Life: 50 yrs.
    b. Start/stops: 3 times per day
    c. Daily Operation:
        (1) At 100% load: 12 hrs. per day
        (2) At 50% load: 10 hrs. per day
    d. Load Changes between 50% and 100% load: 24 times per day
    e. Load Rejections: 6 per year

G. The start/stop sequence and load rejections shall include transient (dynamic) load changes during the final closure of the wicket gates. The following transient (dynamic) load changes shall be considered:

1. Load and stress reversal in the runner blades.
2. Axial load, torque and stress reversal in the shaft and couplings.
3. Sub-atmospheric pressure acting on the wicket gates and the headcover.

H. Supplier shall coordinate torque and stress reversal with the generator supplier to ensure that the generator design is compatible with the turbine.

I. Bearing and Bushing Stresses: Average bearing pressures shall be calculated by dividing the bearing load by the effective projected area of the bearing. Maximum local bearing pressures shall be calculated for asymmetrically loaded bearings and bushings assuming non-uniform linear pressure distribution along the length of the bearing. When calculating maximum local bearing pressures due to shaft deflection, it shall be assumed that the steel shaft is incompressible and bearing pressures are proportional to the compression of the bearing material.

J. Bronze and Other Nonferrous Bushings on Corrosion-Resistant Steel Pins: For normal loading conditions, the average bearing pressure shall not exceed ten percent (10%) of the yield point; the product of bearing pressure in lb/in2 and circumferential velocity in ft/sec shall not exceed 1,400. For overload conditions, the above values may be multiplied by 1.5, and for extreme overload conditions, the limits may be multiplied by 2.25. However, the maximum average bearing pressure in no case shall exceed twenty-five percent (25%) of the minimum yield strength of materials involved, and maximum local bearing pressure shall not exceed fifty percent (50%) of the minimum yield strength of the materials.

K. Permanent Self-Lubricating Bushings on Corrosion-Resistant Steel Pins: Average bearing pressure for permanent self-lubricating bearings for normal loading conditions shall be two-thirds (2/3) of the values recommended by the permanent self-lubricating bearing manufacturer for similar applications. The allowable average bearing pressure for overload conditions shall be limited to 1.3 times the normal allowable pressure. For extreme overload conditions, the values may be increased by fifteen percent (15%) over the overload conditions.

L. Connections: Design requirements for connections generally deviate from the allowable stresses listed above depending on the application and the assumptions. In general, design of connections must consider the nature of the connection (pre-stress, slip critical, friction, single shear, double shear, etc.); stress concentrations; eccentricities, imposed restraints (fixity), and fatigue resistance. The allowable stresses shall be case specific except that maximum pretensioning stress in high strength, pretensioned bolts and studs shall be limited to seventy-five percent (75%) of the minimum yield strength of the bolt material and the maximum stress during operation shall be limited to eighty-five percent (85%) of the ultimate strength, based on the minimum cross section of the bolt and excluding stress concentration effects for the threads, for any loading condition. All bolts subject to variable loading shall be verified for fatigue and the stress variation for fatigue verification shall include stress concentration in the threads. Shaft flange dimensions and shaft coupling bolts shall meet the requirements of ANSI/IEEE 810.

M. Head Losses

1. The net head is determined as the static head minus the hydraulic losses. The hydraulic losses include, trashrack losses, intake and transitional losses, penstock frictional losses and turbine inlet valve losses. These losses are defined by the following formula as:

$$H_L = (1.650 \times 10^{-4} \times Q^2) + (1.028 \times 10^{-3} \times Q) – (3.751 \times 10^{-2})$$

where HL = total hydraulic losses in feet. Q = flow through penstock in cfs.

Therefore, Net head (ft) = Reservoir level (ft) - tailwater level (ft) - HL

2. The turbine supplier shall include draft tube exit losses as head losses in determining turbine net head.

N. Design turbine to have its highest hydraulic efficiency when operating near the rated net head, and to operate throughout the range of operating flow rates and head range specified herein without causing objectionable vibration or noise, excessive cavitation, or rough operation.

1. Excessive cavitation is defined as a condition which results in pitting of the turbine runner and water passage in excess of the amount defined in Section 01750.
2. Temporary operation is defined as 400 hrs of operation at "high turbine load temporary abnormal operating range" and 400 hrs of operation at "low turbine load temporary abnormal operating range." Rough operation is defined as shaft, runner, gate and/or foundation vibrations which are in excess of industry standards.

O. In the event of load rejection or an emergency condition, the turbine shall automatically shutdown in such a manner as to prevent objectionable surges in the penstock. Maximum allowable pressure rise shall not exceed 20% of the static pressure.

P. The spiral case and stay ring, inlet, head cover, bottom ring and discharge ring shall have a minimum design pressure of 1.5 times the maximum static head.

Q. The turbine shall be designed for continuous operation at all flow rates and reservoir water surface elevations within the specified performance envelope. Routine maintenance shall be possible without shutdown. Preventive maintenance or inspection requiring shutdown shall not be required more frequently than annually. The unit shall be designed for unattended operation with remote control and alarm monitoring by a remotely located operator. Routine maintenance shall not be required more often than weekly.

R. Embedded parts shall be designed to allow second stage concrete placement around the parts in continuous monolithic placements at a vertical rate not to exceed two feet per hour. Concrete level differential across the spiral case during concrete placement will be limited to 6 inches maximum.

S. Rotating Inertia:

1. Rotating inertia (WR^2) of the combined turbine-generator shall be such that the maximum momentary speed rise on any load rejection shall not exceed the design capabilities of the turbine-generator or 20% penstock pressure rise, whichever is less or limiting, as verified by calculations performed and provided by Supplier. The generator rotating parts shall have the maximum WR^2 that can be built into a standard size and frame for the machine selected speed without the use of a flywheel. The turbine supplier shall coordinate all details and requirements regarding rotating inertia and speed rise with the generator supplier.
2. Supplier shall indicate in the Bid Forms the turbine and generator WR^2 and corresponding Mechanical Starting Time (Tm) in seconds calculated as Tm = WR^2 x rpm^2 /1.6 x 106 x Hp (rated).

T. Pressure-containing, weld-fabricated components shall be designed, fabricated, inspected, and tested in accordance with the requirements of ASME Section VIII, Division 1, unless otherwise specified. Fabricated components shall be stress relieved prior to final machining.

U. The wicket gate operating mechanism connections, mountings, and other parts of the mechanism subject to such forces shall withstand, without damage, the maximum output of the operating device in conjunction with other worst-case loads and forces on the mechanism.

V. Working stresses, bearing pressure, and other design criteria such as limits of deflection, torsional distortion, and alternating stress shall be determined foremost on the basis of producing an functionally reliable, long-life and trouble-free design.

W. Factors of Safety: Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock per industry standards.

X. Seismically Induced Loads: The turbine shall be designed to withstand an overload condition generated by a seismic event, including seismically induced water pressure experienced at the Project site using Westergaard. See Section 01010 for Project specific seismic design criteria.

Y. Adequacy of Design: The turbine design shall fulfill all the requirements of these Specifications and shall be coordinated and adequate based on the proper application of engineering principles and best practices to ensure good performance, durability, and operation. All items and devices not specifically called out for in these specifications, but which are necessary to provide a complete and reliable machine, or which may be found necessary to stabilize operation, reduce objectionable noise or harmful vibration, or otherwise correct any deficiency or unsatisfactory operation of the machine, shall be furnished.

1.06 DIMENSIONAL TOLERANCES AND SURFACE FINISH

A. Permissible deviations in geometric similarity between the prototype upon which the proposed runner design is based and digital runner design shall within the tolerances set forth in IEC 60193, unless otherwise approved by the Owner. All other dimensional tolerances shall be in accordance with IEC 60193.

B. All surfaces of the runner shall be finished smooth and shall be free from hollows, depressions, cracks, projections, waviness, or other surface imperfections that could cause local cavitation, pitting, or hydraulic loss. Surface waviness shall not exceed the limits provided in IEC 60193.

C. Surface Finish.

1. All surfaces of the runner blades shall provide a smooth-contoured surface. Plate sections shall not be offset, bent, buckled, or depart significantly from the water passage outline.
2. The runner water passages shall be finished smooth and shall be free from hollows, depressions, cracks, projections, or other surface imperfections that could cause local cavitation, pitting, or hydraulic loss.

3. Surface finishes shall not exceed the following limits:
    a. Runner blade inlet and outlet edges: 125 microinches.
    b. Runner blade surfaces (suction side): 125 microinches.
    c. Runner blade surfaces (pressure side): 250 microinches.
    d. Packing/seal contact surfaces: 16 microinches or as recommended by the packing/seal manufacturer.

D. Sharp edges and corners not required for hydraulic, mating, or other reasons shall be filed or deburred smooth.

1.07 OPERATING REQUIREMENTS

A. Normal operation:

1. See Exceedance curves in 1.04 DESIGN PARAMETERS. Normal operation needs to be discussed.
2. Continuous operation with the turbine passing the full range of flows over the full range of heads by opening and closing wicket gates automatically to optimize unit efficiency.
3. Opening and adjusting wicket gates to synchronize unit.
4. Closing wicket gates for normal shutdown.

B. Emergency Operation

1. Closing wicket gates against unbalanced maximum net head and turbine runaway discharge for emergency shutdown.

PART 2 - PRODUCTS

2.01 CAPACITY AND EFFICIENCY

A. Turbine capacity and efficiency shall be based on the values measured on a laboratory scale model or homologous prototype previously tested in accordance with IEC Publication 60193. The turbine shall be designed to have its highest hydraulic efficiency when operating near the rated net head and shall operate throughout the range of operating net heads and discharges listed in this Section, with the corresponding outputs, without causing objectionable vibration or noise, detrimental cavitation, or unstable operation.

B. The Drawings show the preliminary configurations of the water conduits at the turbine inlet and the draft tube. Bidders shall submit, as a part of its Bid, drawings showing all modifications to the inlet conduit(s) and the draft tube that would be necessary in order for the Bidder guarantee cavitation-free operation over the entire turbine operating range.

2.02 TURBINE ASSEMBLY

A. The turbine shall be a horizontal Francis type turbine with steel spiral case, elbow type draft tube and adjustable wicket gates. The turbine and generator suppliers shall make such arrangements as may be necessary to provide a coordinated coupling design and accurate fit between both halves of the coupling between the turbine and generator shafts.

B. All turbine components shall be manufactured according to section 05000 Materials and Workmanship unless otherwise specified. All submittals required under section 05000 shall be submitted prior to beginning fabrication.

2.03 RUNNER

A. The runner shall be new with state-of-the-art hydraulic and mechanical design. Supplier shall submit details and calculations documenting and verifying the basis of Supplier's design and performance guarantees.

B. The runner shall be of the Francis type with the crown and band made of cast stainless steel per ASTM A743, Grade CA6NM and the blades made of forged stainless steel plate. The runner material shall contain 3.5%-6% nickel, 11.5%-16% Chromium to protect against cavitation erosion while maintaining weldability. The runner shall be fabricated weldment of crown, band, and blades welded together in the shop. The joints between the blades and the crown and the band shall be double grooved welded to ensure complete joint penetration through the full thickness and length of the joint. The weld root area shall be gouged to sound metal by a suitable means after sufficient weld metal has been deposited from the first side. The gouged area shall be liquid penetrant tested prior to depositing any weld metal on the second side of the joint.

C. The runner shall be provided with holes through the crown for air admission, venting, and hydraulic balancing as necessary to be compatible with the head cover design.

D. All surfaces of the runner which will be in contact with the water passing through it shall be finished smooth by grinding so that they will be free from hollows, depressions, cracks, or projections that might cause local flow disturbances, cavitation, and pitting. The minimum runner blade surface finish shall be per the requirements specified herein.

E. Hydraulic thrust shall be less than or equal to the generator thrust bearing capacity, with at least 10% margin.

F. The runner shall be homologous to the model in its water passages as verified by use of templates, coordinate measuring machine (CMM) and/or other precision measuring devices. Furnish templates for the Owner's future use in restoring bucket/blade shape to original contours following weld repairs of cavitated areas. Templates shall be made of aluminum. Provide instructions and diagrams for template installation and dimensional checking. Provide storage container for templates. Provide mounting devices for holding the templates in place.

G. The runner water passages, and hydraulic surfaces shall be homologous, within the limits established by IEC 60193, except as modified herein.

H. Weld Repair

1. The Supplier shall provide all weld submittals included in paragraph 1.03 prior to performing any welds.

2. Weld repairs shall conform to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
3. Major weld repairs shall be subject to prior approval by the Owner. A major weld repair is defined as any defect where the depth of the cavity after preparation for repair exceeds the lesser of 20% of the finished thickness or 1 inch, or where the total area exceeds 10 square inches.
4. Cracks and other defects disclosed when the castings are cleaned or during machining operations shall be chipped or grooved by the carbon arc-air process or grinding to sound, clean metal and radiograph, magnetic particle, liquid penetrant, or ultrasonically tested before and after repairs are made.
5. Castings requiring welding repairs at any stage of manufacture after the first annealing and castings involving welding fabrication shall be stress-relieved after repairs are complete, except as modified herein.

I. Nondestructive Examinations (NDE)

1. NDE shall be performed before and after heat treatment.
2. Apply methods, procedures, and acceptance criteria for nondestructive examination of the runner in conformance Supplier's NDE Program, which shall be based on the requirements set forth in CCH 70, Edition 2, Specification for Inspection of Steel Castings for Hydraulic Machines, except as modified below.
    a. Dye penetrant examination (PT): 100% of the runner, 100% of partial penetration welds, and 100% of repaired areas.
    b. Magnetic particle examination (MT): 100% of the runner, 100% of partial penetration welds, and 100% of repaired areas.
    c. Ultrasonic examination (UT): 100% of blades and 100% of full penetration welds.
3. Prepare and submit Supplier's NDE procedures for nondestructive examination of runner castings, fabrications, and welds to Owner for review.

J. Stress Relieving: The heat treatment procedure for stress relieving shall be in accordance with procedures and submitted for review by the Owner.

1. Any requirements for heat treatment to the runner blades shall be submit to the Owner. Runner blades shall be shaped to accommodate for normal warpage that occurs during heat treatment and withdrawal from the heating chamber is taken into account, such that the blade contours after the actual heat treatment are in accordance with the design blade sections.
2. After heat treatment, the actual contours at the root, midspan, and tip of each blade shall be measured by the Supplier, plotted against the corresponding design, and submitted to the Owner for approval; any deviation exceeding the tolerances specified herein shall be corrected.

K. Balancing.

1. The finished runner assembly shall be statically balanced in the shop to meet the requirements of ISO 1940, Balance Quality of Rotating Rigid Bodies, Quality Grade G16.
2. The location and weight of any material added or removed to achieve acceptable balance and the method of attachment of weights shall be recorded. Balancing records shall be available for inspection by the Owner.

2.04 SPIRAL CASE AND STAY RING

A. The spiral case assembly shall consist of the turbine inlet, stay ring, stay vanes, and spiral case segments. The assembly shall be a welded fabrication and properly shaped to be homologous to the model. The spiral case shall be of the full spiral case type.

B. The size and design of the spiral case shall take into account physical constraints with respect to shipping and access into the powerhouse. The design shall incorporate field-welded joints where needed.

C. Design requirements for embedment of the spiral case and loads transmitted to adjacent concrete shall be clearly communicated in writing to the Owner.

D. The spiral case shall be specifically designed and adequately reinforced to withstand the weight and maximum operating loads of the turbine-generator assembly resulting from all normal and emergency operating conditions, including, but not limited to, transient pressures, seismic conditions, overspeed, and short circuit forces. The design of the spiral case and stay ring assembly, requirements for embedment and loads transmitted to adjacent concrete shall be clearly communicated in writing to the Owner.

E. Turbine Inlet

1. The turbine inlet shall feature a bolted flange or welded connection to allow for a spool and expansion joint between the turbine inlet and turbine inlet valve. The internal diameter of the turbine inlet, expansion joint, and turbine inlet valve shall match as close as possible, except the valve shall have a standard diameter.
2. The turbine inlet shall be fitted with four piezometer taps for inlet head measurement, located and designed in accordance with the requirements of IEC 60041.
    a. Piezometer Piping and Fittings: Stainless steel with Parker A-Lock fittings.
    b. Extend piezometer piping for the turbine inlet to a common location on the turbine and provide a manifold, pressure gauge and pressure transducer.
3. A pipe connection and ball valve shall be provided on the invert of the inlet pipe of the spiral case, for a drain line connection.
4. Air inlet/release valve and isolation valve shall be provided at the top of the inlet to release air during filling of the turbine and vent during draining.

F. Spiral Case

1. The spiral case shall be a welded fabrication and properly shaped to be homologous to the model. The spiral case shall be designed to be permanently embedded in concrete and shall be adequately stiffened externally and provided with proper anchorage to the concrete.
2. The spiral case shall be provided with a steel drain box at its low point with necessary parts for embedment in the concrete. The drain box shall be constructed so that the spiral case can be drained completely via a flanged connection at the low point of the drain box. The drain box shall be protected by a suitable removable inlet grating.
3. Support feet shall be fabricated integral with the spiral case and finished machined on the support surface.

4. The spiral case shall be fitted with four piezometer taps for Winter-Kennedy (W-K) differential pressure measurement, located and designed in accordance with the requirements of IEC 60041.
   a. Piezometer Piping and Fittings: Stainless steel with Parker A-Lock fittings.
   b. Extend piezometers piping for the W-K taps to a common location and furnish a differential pressure transducer to be used for flow measurement calculations.
5. A sufficient number of machined pads for the application of jacks and fastenings for hold-down bolts, jacks and turnbuckles shall be furnished for positioning and leveling the spiral case during erection and for supporting and holding it in proper position while the concrete surrounding the spiral case is being placed.
6. The spiral case design shall include provisions for tie-off points for safety during maintenance or inspections.

G. Stay Ring and Stay Vane Assembly

1. The stay ring shall be made of welded plate steel, sectionalized as required for handling and shipment. Stay ring segments, if sectionalized, shall be doweled and welded or bolted together. The stay ring shall be completely machined in the shop and shall be designed so that all necessary adjustments during its installation can be performed without the need for any field machining.
2. The stay vanes shall be designed to withstand tension, due to the outward reaction at the stay ring due to water pressure in the spiral case in excess of the restraining forces of the surrounding structure. Provision shall be made in both rings, opposite the vanes, for attachment of large tension anchor bars, which shall be furnished by the Supplier.
3. The stay ring shall be provided with the eyebolts and/or lugs for attaching slings for lifting as spiral case/stay ring sections. A sufficient number of machined pads for the application of jacks and fastenings for hold-down bolts, jacks and turnbuckles shall be furnished for positioning and leveling the stay ring during erection and for supporting and holding it in proper position while the concrete surrounding the stay ring is being placed.
4. The diameter of the stay ring shall be sufficient to avoid excessive overhang of the wicket gate tips over the curve of the bottom ring / discharge ring when the wicket gates are open. The stay ring vanes shall be suitably shaped and oriented in the radial direction to guide the entering water properly to the wicket gates.
5. Provisions shall be made to ensure the free passage of air and grouting material during embedment.
6. The stay vanes shall be fabricated from steel plate or cast steel. The stay vanes shall be ample to support the weight of the structure and machinery loads from above with the spiral case empty so that it shall become an integral part of the structure. After welding the stay ring shall be thermally stress relieved prior to machining.

H. The Supplier shall furnish suitable provisions for adjustment of level, alignment, and to compensate for distortions for misalignment due to field welding or concrete embedding operations.

I. The spiral case or turbine inlet shall be provided with three watertight and airtight 36 inch diameter mandoors, one on each side, and one at the top dead center, each equipped with hinged cover and gasket, stainless steel hinge pins, corrosion-resisting steel bolts, and with jack screws, opening outward. The mandoor shall also be furnished with a rugged sight gauge and valve to provide visual indication when the spiral case is dewatered. The inside surface of the door shall be flush with the inside hydraulic profile of the wetted parts.

2.05 BOTTOM RING AND DISCHARGE RING

A. The bottom ring and discharge ring shall be a welded fabrication and properly shaped to be homologous to the model. The rings shall be sectionalized with bolted and doweled flange connections as required for shipment and handling. The rings shall be thermally stress relieved after welding and prior to machining.

B. The discharge ring shall be designed to be permanently set in concrete and shall be adequately stiffened externally and provided with proper anchorage to the concrete. The ring shall have suitable stiffeners to allow it to be embedded in 2nd stage concrete without distortion.

C. The rings shall be furnished with suitable attachment lugs, adjusting devices and anchorage points to position it during installation and to prevent movement during embedment and vibration during operation. Provisions shall be made to ensure the free passage of air and grouting material during embedment.

D. That portion of the discharge ring opposite the runner (a minimum of 12 inches upstream and 18 inches downstream of the runner centerline) shall be fabricated from stainless steel plate per ASTM A240 or stainless steel weld overlay and the portion downstream of the blade centerline shall be spherically machined for close runner blade clearances at all blade angles.

E. The wetted hydraulic surface of the rings shall be smooth and shall have no abrupt changes in direction or offsets. The lower end of the discharge ring shall be provided with a flanged or field-welded connection for attaching the draft tube liner. If a flanged connection is provided, the flange shall be drilled in the factory. This connection shall be machined to fit the upper diameter of the draft tube liner. The connection shall be provided with a V-groove on the inside of the joint for seal welding in the field after assembly.

F. The bottom ring shall support installation of wicket gate bushing housings and replaceable facing plates. The bushing housings shall be for lower wicket gate bushings and stem seals. The housing in the bottom ring shall be accurately line bored in the shop with the wicket gate cartridges in the outer headcover to maintain accurate concentricity and alignment with the wicket gate bushings.

G. Removable and renewable stainless steel facing plates per ASTM A240 shall be provided on the bottom ring below the wicket gates. The facing plates shall be held in place with flush-mounted stainless steel patch bolts and sealed on the underside with a suitable sealant. The finish surface of the facing plates shall be accurately machined to minimize waviness. The hardness of the facing plates shall be at least 40 BHN different than the wicket gates. The Owner will consider other facing plate designs as an option bid.

2.06 DRAFT TUBE LINER

A. The draft tube liner shall be fabricated from steel plate and properly shaped to be homologous to the model to ensure correct hydraulic performance. The steel liner shall extend through the elbow section of the draft tube and end when the water velocity in the draft tube is less than an average velocity of 11.5 ft per sec before transitioning to formed concrete and the rectangular cross-section.

B. The draft tube liner shall be designed to be permanently set in concrete and shall be adequately stiffened externally and provided with proper anchorage to the concrete. The liner shall have suitable stiffeners to allow it to be embedded in 2nd stage concrete without distortion.

C. The liner shall be furnished with suitable attachment lugs, adjusting devices and anchorage points to position it during installation and to prevent movement during embedment and vibration during operation. Provisions shall be made to ensure the free passage of air and grouting material during embedment.

D. Drains and Filling

   1. The draft tube shall be provided with a steel drain box at its low point with necessary parts for embedment in the concrete. The draft tube drain box shall be constructed with a flanged connection at its low point so that the draft tube can be completely drained.
   2. The drain box shall be protected by a suitable removable inlet grating. Holes in the grating shall not be larger than 3/8 in. square or round.
   3. A filling connection with intake grating shall be provided on the draft tube.

E. Pier Nose

   1. A pier nose shall be provided if the draft tube is designed with a center pier. The pier nose shall be fabricated from steel plate and shall have suitable stiffeners to allow its embedment into concrete without distortion.
   2. The pier nose shall be furnished with suitable attachment lugs, adjusting devices and support points to position during installation and to prevent flotation during embedment and vibration during operation.

F. A watertight and airtight mandoor (approximately 36” x 42”) equipped with hinged cover and gasket, stainless steel hinge pins and fasteners, corrosion-resisting steel bolts, and with jack screws, opening outward into the access passageway, shall be provided in the draft tube liner. The mandoor shall also be furnished with a stainless steel piezometer tap and pressure gauge and a rugged sight gauge and valve to provide visual indication when the draft tube is dewatered. The inside surface of the door shall have a fairing plate to make the hydraulic surface flush with the inside of the draft tube liner.

G. A maintenance platform shall be furnished to facilitate inspection and maintenance of the runner from the draft tube mandoor. The platform shall allow for access to upper section of turbine blades, where it is installed. It shall be made of aluminum components, stamped with load capacity, and shall be sectionalized so the weight of each section facilitates easy assembly and disassembly by the Owner’s staff through the draft tube mandoor. Pockets or removable brackets, or both, shall be provided in or on the draft tube liner for supporting the main members of the maintenance platform. The support pockets or bolt holes through the liner shall be sealed on the exterior by watertight covers. The platform shall have non-slip type floor plates and shall be complete with all accessories required for its intended use. The capacity of the maintenance platform shall be as follows:

1. Distributed Load: 50 lbs per square ft.
2. Concentrated Load: 300 lbs.

2.07 STILLING BASIN

A. The Turbine supplier shall design and supply a stilling basin if required for stable operating over the entire range of heads and flows. Location and details of the stilling basin shall be included on general arrangement drawings. Adjustments to the net head shall be performed according to the stilling basin design and shall be reflected in the bid form documents.

2.08 HEADCOVER

A. The headcover shall be a single piece Bolts, dowels and O-ring seals shall be provided at the interface between headcover and the stay ring and bottom ring. Provisions for jack screws shall be provided on each headcover to facilitate disassembly. Eye bolts shall be furnished for each headcover section for lifting and handling.

B. The headcover shall be a weldment of structural steel and shall be thermally stress relieved prior to machining, but subsequent to all welding.

C. Provide removable deck structure and plates above the headcover to provide access around the turbine pit. Particular attention shall be given to providing good access to the shaft seal and headcover drain.

D. The headcover shall support removable wicket gate cartridges and replaceable facing plates. The cartridges shall house the upper and intermediate wicket gate bushings and packing box. The cartridges shall be accurately positioned, bolted and doweled to the outer headcover to maintain accurate concentricity with the lower wicket gate bushings located in the bottom ring. Cartridge removal and re-installation shall be possible without removing the wicket gates. The cartridges in the outer headcover shall be accurately positioned and line bored in the shop with respect to the wicket gate bushing housings in the bottom ring to maintain accurate concentricity and alignment of the wicket gate bushings.

   1. The headcover, in conjunction with the stay ring, shall be designed to form a rigid assembly.
   2. The headcover shall be so designed as to provide drainage from spaces around the gate cartridges and so that water cannot collect in these spaces.
   3. The gate cartridges shall incorporate wicket gate stem packing boxes or similar Owner-approved seals. The design and seal/packing selection shall be well proven and highly reliable. If Supplier furnished packing boxes the adjustable packing glands shall be bronze. Packing or seal leakage shall be zero. Supplier shall submit material samples of proposed gate stem packings/seals accompanied with drawings and catalog data as part of the Owner’s submittal review and approval process.

4. Removable and renewable stainless steel facing plates per ASTM A240 shall be provided on the headcover above the wicket gates. The facing plates shall be held in place with flush-mounted stainless steel patch bolts and sealed on the underside with a suitable sealant. The finish surface of the facing plates shall be accurately machined to minimize waviness. The hardness of the facing plates shall be at least 40 BHN different than the wicket gates. The Owner will consider other facing plate designs as an option bid.
5. The headcover shall support the shaft seal and operating ring. The runner side of the headcover shall be designed to fully homologous and minimize hydraulic losses and to provide free and uniformly streamlined flow to the runner. Tapped and plugged holes shall be furnished to permit drainage of the headcover when the unit is dewatered.
6. Design of the headcover shall incorporate the supports and axial and radial guides for the wicket gate operating ring. All headcover surfaces in contact with self-lubricating guides or bearing strips that are used to guide the gate operating ring shall be stainless steel (minimum of 0.25 inches thick).
7. Design and arrangement of the headcover shall facilitate installation, removal and maintenance of the shaft seal.
8. If required for turbine design, air admission piping shall be incorporated into the headcover.
9. Hand holes shall be provided through the headcover, properly sealed for normal operation and through which electric cords, lamps, and air supply lines may be extended for work across the headcover.

2.09 WICKET GATES AND GATE MECHANISM

A. The wicket gates shall be cast stainless steel in accordance with ASTM A743, Grade CA6NM.

B. Each wicket gate shall be accurately machined smooth, free of waviness, projections, depressions, or other surface irregularities. Appropriate machining techniques shall be used to ensure that all of the gates have the same height and other physical dimensions and that the wicket gate ends are parallel to each other and are perpendicular to the wicket gate axis of rotation. Gate-to-gate contact surfaces shall be accurately machined and finished to minimize the clearance between mating surfaces when the gates are closed.

C. The number of turbine wicket gates, stay vanes, and runner blades shall be coordinated so as not to cause harmful flow-induced vibrations in operation of the turbine. The wicket gates shall be designed so that the hydraulic moment characteristics of the gates will have a self-closing tendency over the range of positions from full gate opening to approximately the speed-no-load position, upon loss of governor oil pressure. If it is not practicable to have the wicket gates with a self-closing tendency, then a spring-loaded closing mechanism shall be provided.

D. The turbine will be idle for certain periods of time with full hydrostatic pressure against the wicket gates, and provisions shall be made to reduce gate leakage to a minimum.

E. Three self-lubricated guide bushings/bearings shall be provided for each gate, one located in the bottom ring and the other two located in the outer head cover, one below and the other above the packing box. Each gate stem shall also be provided with self-lubricated thrust bearing or collar designed to carry the weight of the gate and to resist any upward thrust of the gate. Suitable means shall be provided at the top of each gate stem for readily adjusting and maintaining the adjustment of each gate in the mid-position between the outer head cover and the bottom ring facing plates without otherwise disturbing the gate stem assembly.

F. Wicket gate stems shall be amply sized to make it possible to install hardened stainless steel sleeves at a future date, should excessive wear occur on the stems. Supplier’s shop drawings shall show two wicket gate designs. One design being the as-supplied design without stem sleeves and another design with the sleeves installed.

G. Wicket gate stems seals shall be provided on the inboard side of the bushings nearest the water passage to prevent leakage and silt and sediment from entering the guide bushing cavities. The seals shall be highly reliable and highly wear resistant. Supplier shall submit material samples of proposed gate stem seals accompanied with drawings and catalog data as part of the Owner’s submittal review and approval process.

H. Links and Levers

1. Each wicket gate shall be interconnected to the gate operating ring with adjustable links and gate levers. Every other lever shall be equipped with a shear pin and friction device. Each gate shall be individually adjustable with an eccentric pin installed in each link to facilitate alignment and adjustment. The Owner will consider bending links and other designs as an option bid.
2. In the event a gate becomes blocked, the shear pin shall allow the affected gate(s) to remain in the blocked position during operating ring movement and prevent the affected gate(s) from fluttering or moving freely. In addition, wicket gate stops shall be provided to limit the range of wicket gate motion.
3. Two gate lever aligning tools shall be provided for safely pulling any gate into position so that a shear pin can be replaced.

I. Gate Operating Ring

1. The gate operating ring for distributing the gate servomotor forces and movements to all the wicket gates simultaneously, shall be located inside the gate circle and shall be arranged to allow convenient access to the and shaft seal. The ring shall be made of fabricated steel and shall be of rigid design. It shall be centered by self-lubricating radial strips/bearings and supported and retained by top and bottom self-lubricating axial strips/bearings.
2. Surfaces with sliding contact shall be arranged for application of a suitable greaseless type bearing material. The structure supporting the operating ring shall be of adequate strength and stiffness to prevent excessive deflections of the structure or other parts when the gate operating ring is subjected to unbalanced thrust of one servomotor with the other servomotor blocked. The gate operating ring shall be thermally stress relieved prior to machining, but subsequent to all welding operations. The gate operating ring shall be designed to receive the gate servomotor connecting rods and pins at opposite points of the ring, and all of the gate links and pins as required by the design.

J. Connecting Rods

1. The connecting rods between the gate servomotor piston rods and gate operating ring shall be of steel, with self-lubricated bushings/bearings.

K. Wicket gate leakage shall be measured during the warranty period and shall not be greater than 0.3% of the full gate turbine discharge under the rated net head.

2.10 GATE SERVOMOTORS

A. The turbine shall be provided with oil-pressure-operated, double-acting; mill type hydraulic cylinder servomotors having a capacity sufficient to supply the maximum force necessary to operate the wicket gates with the minimum operating oil pressure in the governor oil pressure tank. The operating oil pressure shall be determined by the Supplier based on the nominal governor system, HPU, and TSV Actuator operating pressure specified in Sections 15970, 15980, and 11510 respectively. With the minimum operating oil pressure in the governor system, and with an adequate supply of oil, the servomotor shall be capable, under maximum operating conditions, of moving the wicket gates a full-opening stroke or a full-closing stroke in the minimum time required.

B. The servomotors shall be supported on suitable machined pads forming integral parts of the turbine pit liner or headcover and shall be designed to withstand the maximum reactions in both directions. Each servomotor shall be provided with an adjustable plate or shims for proper alignment of the servomotor during erection.

C. The servomotor cylinders shall be made of cast steel or welded steel plate. They shall be accurately bored and shall be provided with SAE flanges at the pressure ports for connecting oil piping and with packing boxes or a similar Owner-approved design to prevent leakage of oil along the piston rods. Provide V-ring type packing or similar means of sealing that is well proven and highly reliable. The piston rod shall be provided with a hard chrome plated outer surface with a ground and polished surface. A rod wiper shall be furnished for cleaning and scraping the rod.

D. The servomotor pistons shall be made of cast steel or cast iron, and each piston shall be fitted with not less than three cast iron piston rings suitably shaped to give close contact and uniform pressure to the cylinder walls and to prevent leakage of oil past the pistons.

E. The servomotors shall be designed and located so that the force for moving the wicket gates will be divided approximately equally between the two cylinders and will be applied in substantially equal magnitude to opposite sides of the gate operating ring.

F. The servomotors shall be equipped with an adjustable means of retarding the rate of closure from slightly below the speed-no-load position, for maximum head, to the fully closed position, so as to minimize pressure rise in the penstocks and to prevent shock loads in the gate mechanism when the gate bodies contact each other.

G. Suitable mechanical devices shall be provided on the servomotors to lock or restrict the movement of the gate operating mechanism. Each device shall be capable of holding the gate against the maximum effort of the gate servomotors and the unbalanced hydraulic force on the wicket gates.

H. An adjustable gate stop on one gate servomotor shall be provided to limit the motion of the wicket gates in the opening direction in order to limit the load on the generator, if needed. Provisions shall be made for manual operation of this device.

I. A brass scale and pointer and gate position feedback transducer shall be provided on one of the servomotors for position indication. The gate position feedback transducer shall be a scalable magneto-restrictive linear displacement transducer (MLDT) with 4-20mA outputs corresponding to gate position. External power for this device shall be 24Vdc. All necessary mounting hardware for the body and push arm of this device shall be furnished. A shielded cable sufficiently long to reach the turbine auxiliary terminal box shall be supplied.

2.11 SHAFT

A. The turbine runner shall bolt directly to the shaft according to Section 16210 – Synchronous Generator.

2.12 SHAFT SEAL

A. Shaft seal design must be coordinated with the shaft and shaft sleeve design of the Generator Supplier if different from the Turbine Supplier. See Section 16210 – Synchronous Generator for Shaft and Shaft Sleeve requirements.

B. A shaft seal shall be provided where the Turbine-Generator shaft passes through the head cover. The shaft seal shall be a stuffing box type with adjustable packing, axial mechanical seal type or a similar Owner-approved design. The design shall be well proven and highly reliable. The shaft seal shall be easy to access, maintain and adjust and arranged so that it can be inspected and sealing elements replaced in a simple manner. The Supplier shall provide data and other evidence substantiating the quality and durability of the sealing elements and overall design for approval by the Owner early in the design and submittal process.

C. Packing or sealing elements shall be removable and replaceable without removing the turbine shaft. Packing or sealing elements shall be low-friction and low-wear, and providing low shaft sleeve wear.

D. The shaft seal housing shall be of heavy construction. The housing shall be a separate component, bolted and doweled to the head cover and split axially to facilitate installation and removal. Bronze and stainless steel materials shall be used extensively throughout the shaft seal design.

E. If a traditional stuffing box with packing rings is provided, the design shall include a catch basin to control leakage, lantern ring and bronze wear ring to maintain a close running clearance with the turbine shaft and prevent extrusion of packing out the bottom of the stuffing box.

F. The shaft seal shall be provided with bronze or stainless steel water injection connections.

G. The shaft seal shall be cooled and lubricated by clean filtered water provided by the cooling water system specified in Section 15400.

H. The shaft seal shall be provided with a cooling water flowmeter.

2.13 AIR ADMISSION (if required)

A. Supplier shall provide an air admission system for admitting atmospheric air through the head cover. Air admission is not desirable under normal operating ranges due to air entrainment and reduced operating efficiency.

B. The air admission or vacuum breaker valve shall operate automatically with provision for manual control also. The valve shall be reliable and equipped with features to prevent rapid movement and slamming.

C. The air valve and all air admission piping installed on the head cover and in the turbine pit shall be stainless steel. Furnish all valves, pipes, fittings, and supports for a complete and operational system.

2.14 SELF-LUBRICATING BUSHINGS AND BEARINGS

A. Anywhere greaseless or self-lubricating materials are used in the turbine, stainless steel wear or mating surfaces shall be provided. Stainless steel surfaces shall have a surface finish and hardness as recommended by the manufacturer of the bushings/bearings.

2.15 PIPING

A. The Equipment Supplier shall furnish all piping, valves, and appurtenances required for seal water, cooling water, and/or air admission.

B. Piping shall be shop fabricated to the extent practical for field installation with reasonable trim allowance.

C. Piping shall be furnished with all necessary fittings and supports. Pipe and fittings shall be ANSI standard.

2.16 ALARMS AND SHUTDOWN DEVICES

A. The Supplier shall furnish protection devices mounted on the turbine system as listed below.

1. Shaft vibration sensors – 2 radial probes 90 degrees apart, plus single axial probe suitably located, each with alarm and shutdown levels field adjustable
2. Stuffing box injection water flow switch – alarm and shutdown
3. Shaft seal water flow switch – alarm and shutdown for runner hub seal and shaft seal.
4. Differential pressure switch for shaft seal filter alarm and shutdown.
5. Pressure switch for stuffing box injection water alarm and shutdown

B. The devices shall be suitable to perform the indicated function directly, or through auxiliary devices in the control switchboard (to be supplied by others).

C. Contact ratings shall be 120V AC and 125V DC with a NEMA A300 (minimum) rating.

2.17 ACCESSORIES

A. The following accessories shall be supplied for each turbine:

1. Stuffing box flow meter.

2. Turbine instrumentation panel, including pressure gage for inlet pressure and a compound pressure/vacuum gage for draft tube pressure/vacuum.
3. Gage pressure transmitter for turbine inlet static pressure. Transmitter shall be electronic age pressure type with 4-20mA output. Transmitter shall have valve manifold to permit off-line recalibration and zero check.
4. Differential pressure transmitter for draft tube pressure/vacuum. Transmitter shall be electronic type with 4-20mA output. Transmitter shall be furnished with valve manifold to permit off-line recalibration and zero check.
5. Limit switches for wicket gates 0% and 100% indication.
6. Limit switches (4) capable of field adjustment to operate at intermediate wicket gate openings.
7. Gate servomotors shall be double acting, suitable for operation up to 1500 PSIG and supplied complete with stop ring, cushioning and flow control valves.
8. Resistance temperature devices, (RTD) shall be furnished where called for in this Section. RTDs shall have the following characteristics:
    a. Dual element having individual three conductor leads.
    b. RTDs shall have integral junction box where practicable.
    c. RTDs shall be Platinum, 100 ohm, with alpha of 0.00385 corresponding to DIN curve.
    d. Accuracy shall be 0.5 degree C meeting 0.1% DIN tolerance.
9. Turbine terminal cabinets shall be furnished with all limit switches and electrical accessories terminated on 600V rated terminals. Cabinets shall be NEMA 12 with 20% spare terminals.

2.18 LIFTING AND HANDLING DEVICES

A. The Supplier shall design and furnish a complete set of runner and tower assembly lifting devices, including lifting beams, lifting eyes, lifting blocks, support brackets, adapter plates and appurtenances.

B. One set of all lifting devices for connecting major components and assemblies to the crane hooks, including all lifting beams, pins, shackles, slings and other devices required to connect the crane hooks to any turbine components and/or assemblies. Also a shaft lifting bracket with bolts, nuts and pins for attaching to the top of the turbine shaft, for lifting the runner, shaft and inner head cover with a crane and for upending the shaft from the horizontal to the vertical position. A protective plate with integral roll-bar shall be provided for the runner end of the shaft to facilitate upending the shaft.

C. Lifting devices shall be designed and load tested in accordance with ASME B30.20. Each lifting device shall be 100% VT and 100% MT inspected following the load test and prior to finish painting. Documentation regarding the load testing and inspections shall be provided to the Owner prior to use of any fixture or device.

D. The rated capacity shall be clearly and permanently indicated on each lifting device. Each lifting device shall be permanently labeled with a unique identification name and number.

2.19 NAMEPLATE

A. A nameplate shall be provided. The nameplate shall be brass (3/8 inch thick), and shall be engraved with raised lettering, a black leatherette background and a single raised border with the following information:

1. Manufacturer’s name.

2. Manufacturer’s model number and serial number plus turbine type.

3. Project name and Unit number

4. Rated output.

5. Rated net head.

6. Rated discharge.

7. Best efficiency point.

8. Rotation speed and direction of rotation.

9. Year of manufacture

10. Runner diameter

2.20 SPARE PARTS

A. The Supplier shall supply the following spare parts for the turbine:

1. Two complete sets of all packings and seals
2. Complete set of main shaft bearings (optional bid item)
3. Two spare wicket gates.
4. One-half set of wicket gate levers.
5. One complete set of wicket gate bushings.
6. Two complete sets of wicket gate shear pins.
7. One sleeve for the main shaft where it passes through the seal.
8. One spare switch and control of each type
9. One set of access manhole gaskets for each manhole.

B. The Supplier shall also supply one complete set of special tools and runner blade templates required for maintenance of the turbine.

2.21 SAFETY GUARDS

Safety guards for all moving or rotating parts shall be provided in accordance with OSHA and California requirements.

2.22 COATING

A. General: Refer to Section 09900 for general painting requirements. After the equipment has been fabricated and inspected, the Supplier shall apply protective coatings to all surfaces subjected to corrosion. Weld spatter, burns, and other objectionable irregularities shall be carefully removed and repaired. All oil, grease and dirt shall be removed from the surfaces using suitable solvents and clean wiping materials.

B. Grit Blasting: All surfaces to be coated, except machined surfaces, shall, prior to coating, be grit blasted to "near-white" metal in accordance with the requirements of SSPC.

C. Coating Materials:

1. All exterior surfaces shall be coated with ANSI 70 gray zinc rich primer. The primer shall be applied in accordance with the primer manufacturers' printed recommendations by brush or spray method, to produce a minimum dry fill thickness of three mils.
2. Interior surfaces shall be coated with not less than one coat of corrosion-resisting paint in accordance with the manufacturers' standard practice. Coordinate with 09900.
3. Machined surfaces which are in sliding contact with other machined surfaces during operation of the equipment shall be coated with a suitable coating which will provide adequate lubrication and prevent corrosion during shipping, storage and installation. All other machined surfaces subject to corrosion, except those to be assembled at the Supplier's plant, in permanent contact with the surfaces of other components shall be coated, along with unmachined surfaces.
4. The finish coat on all exterior surfaces shall be ANSI 70 gray, acrylic lacquer. Minimum dry film thickness shall be five mils. Coordinate with 09900
5. Wetted parts shall be coated with a primer suitable for coating with coal tar epoxy or other suitable coating after equipment installation. Coordinate with 09900.
6. All coating materials shall be subject to the review of the Engineer for compliance with the Specifications.
7. The Supplier shall supply touch-up paint (one u.s. gallon minimum) and associated primers for each type of coating used on the various parts.

2.23 SHOP ASSEMBLY AND TESTS

A. The turbine shall be assembled in the shop to verify design, construction, and machining for proper alignment, fits, and clearances. Parts shall be properly match-marked, identified, and doweled to insure correct assembly and alignment in the field. The turbine case with stay ring shall be assembled together. The gate servomotors may be assembled and tested separately.

B. Controlling dimensions and small clearances of the assemblies shall be measured and recorded on illustrated shop inspection forms, showing both the design drawing dimensions and the actual measured dimension.

C. The assembled wicket gates shall be operated through at least three cycles of their full movement at a rate of movement of not less than 120 seconds for full movement, to demonstrate that the gates and gate mechanism function properly without interference or binding.

D. All components and devices subject to governor oil pressure, lubricating oil pressure, grease pressure, compressed air pressure, and cooling water pressure shall be shop tested at 1.5 times the design maximum operating pressure for a period of not less than 30 minutes, with no leakage or permanent deformation allowed.

E. Submit all applicable Welding Procedure Specifications, Welder Performance Qualification records, and material test certificates.

PART 3 - EXECUTION

A. Turbine shall be shipped and stored in accordance with manufacturer's instructions.

3.02 INSTALLATION

A. Installation will be under separate contract by Contractor, subject to the technical supervision of the Equipment Supplier's Representative. Equipment Supplier shall include cost for turbine representative to be on-site during installation in the Bid Form.

3.03 START-UP AND INITIAL OPERATION SERVICES

A. Operating Functions: Equipment Supplier's Representative shall supervise all operating functions during start-up and initial operation. The necessary personnel to instruct Owner's operating staff in matters regarding the operation and maintenance of the equipment shall also be provided. Operating staff will participate in performing all operating functions during start-up and initial operation under the Equipment Supplier's Representative supervision.

B. Preparation for Starting the Unit:

1. All equipment including gauges, instruments, controls, valves, lubricating devices, flow indicators, filters, pumps, etc. shall be carefully checked for proper operation before starting the unit. All gauges, instruments, controls, temperature devices, relays, contactors, meters, and associated electrical and mechanical devices shall be calibrated. Oil pumps and piping shall undergo a 24-hour period of operation and inspection to be sure of correct performance and the absence of leaks. All components of the turbine, generator, and auxiliary equipment shall be carefully inspected to be certain that all foreign matter has been removed.
2. All water supply lines, including strainers, shall be checked to be sure of proper flow to the various parts of the unit.
3. Before watering the unit, a final check-out shall be made of the operational readiness of the generator, turbine, and associated auxiliaries.
4. An operation test shall be performed on all relays, indicators, thermometers, speed switches, resistance temperature detectors, and flow switches to verify correct calibration, adjustment, and operational readiness.
5. At least 12 weeks prior to initial startup, the Equipment Supplier shall submit a report prepared by the turbine manufacturer, describing and summarizing transient analyses which have been performed on the water conveyance system,

including the turbine and generator characteristics. At a minimum, the report shall include cases for load-on, load-off, 25%, 50%, 75% and 100% load rejection. The report shall include graphical representation of wicket gate position, turbine-generator speed, and turbine pressure all in the same time domain.

6. A check-off list procedure shall be established in preparation for starting the unit. The Equipment Supplier shall prepare and submit for Engineer's approval a detailed check-off list. Equipment Supplier's Representative shall sign off on each item indicating that it is ready for use in the start-up and initial operation of the Project.
7. Turbine and generator manufacturer's representative shall certify correct installation, in compliance with manufacturer's requirements.

C. Initial No-Load Run.

1. Perform no-load mechanical run to check shaft run-out and bearing temperatures and to run-in the bearings. The Owner will assist with watering up and operating the unit. Shutdown the unit in order to make any desired adjustments. In some cases, dewatering and inspecting internal turbine parts or water passages may be required.
   a. Bump start unit spinning and immediately let it spin down to rest. Then Increase unit speed in increments of 25% of rated speed up to 100% rated speed. Wait between the steps to allow bearing temperatures to stabilize. Observe and record:
      (1) Bearing vibration.
      (2) Shaft vibration.
      (3) Bearing temperatures.
      (4) Time required for bearing temperatures to stabilize at each speed increment.
   b. Perform no-load test at each speed until bearing temperatures stabilize for at least 2 hours.
   c. During no-load test perform the following checks and adjustments:
      (1) Operation of governor gate timing at rated speed.
      (2) Operation of starting and stopping controls, including emergency shut-down devices.
      (3) Operation of speed switches.
      (4) Setting of speed indicator.
      (5) Overspeed test.
      (6) Setting thermometers, pressure gauges, electrical indicating instruments, and other devices.

D. Initial Load Run.

1. After the unit has been synchronized and connected to the electrical system, perform incremental load tests with load increased in small steps and with observations of temperature rise and of the operation of the equipment. When full load has been reached, it shall be maintained for 8 hours to allow a careful check of temperature rise of bearings and generator windings, observations of general unit operation, and to make any adjustments necessary to assure continued successful operation.

2. Conduct tests to determine the operating characteristics of the generating unit. Testing shall be coordinated with the Owner. As a minimum, repeat the following tests specified in paragraph 3.03C and record operational measurements. Also refer to Section 16950 for generator testing.
    a. Head.
    b. Wicket Gate Opening.
    c. Generator Output.
    d. Shaft Runout.
    e. Vibration.
    f. Bearing Temperatures.
    g. Pressures.
    h. Governor capacity.
    i. Generator Air Cooling Water.
    j. Brake Timing.
3. Prepare and submit test procedures and schedule, a list of tests to be conducted, and those requiring the Owner involvement during testing.
4. Submit all test data and calibration records for review.

E. Load Rejection Tests.
1. Load rejection tests shall be performed at 25, 50, 75, and 100% gate opening up to maximum capability of unit. Make any adjustments at each load rejection test before proceeding with the next test to ensure that the unit will not exceed the admissible operating and safety limits at the next greater load rejection.
2. During the period of load rejection tests, all precautions shall be taken to ensure that specified values of transient pressures and speeds, and specified turbine unit stresses, will not be exceeded. The precautions may include setting of governor timing at rates slower than design rates. When adjustments are made on governor or regulating devices, the tests made prior to such adjustments shall be repeated.
3. Measure and record the following steady-state data prior to each load rejection:
    a. Gate position.
    b. Load.
    c. Headwater elevation.
    d. Tailwater elevation.
    e. Spiral case pressure.
    f. Draft tube pressure.
4. Measure and record versus time the following transient data for each load rejection.
    a. Wicket gate position and gate timing.
    b. Shaft speed.
    c. Turbine case pressure.
    d. Draft tube pressure
    e. Generator power and voltage.
    f. Shaft runout.
5. Plot shaft speed, wicket gate position, and turbine case pressure versus time graph.

3.04 FIELD TESTING SERVICES

A. General: After the equipment has been installed and is ready for operation, it shall be tested under the supervision of the applicable manufacturer's test engineer to determine whether the guarantees and the requirements of the Specifications and other applicable requirements of the Contract Documents have been fulfilled. The Installation Contractor and the Equipment Supplier shall cooperate with Owner to establish a mutually satisfactory date for testing. The Equipment Supply contractor shall be responsible for supervision and test procedures for all field tests on the equipment supplied by the Equipment Supplier.

B. Unit Capacity and Index Tests: Unit capacity and index tests shall be performed on the unit(s) to verify that the power output guarantee has been fulfilled and to determine the shape of the efficiency-power curve(s). The tests shall be conducted in accordance with the Provisions of ASME PTC 18, "Performance Test Code for Hydraulic Prime Movers," including its supplement on "Index Method of Testing." Net head shall be determined by subtracting the tailwater elevation from the headwater elevation and total penstock and intake losses, including corrections for the velocity head at the net head measuring sections in the turbine inlet and draft tube using the discharge estimated from the turbine manufacturer's curves of expected performances.

The turbine output shall be determined from electrical measurements of generator output and the known generator, and main power transformer losses. All subsequent adjustments in the turbine working parts as may prove necessary or desirable to secure optimum turbine performance shall be made. Should the rated net head condition not exist at the time of the test, the turbine output shall be adjusted by the ratio of the heads to the 3/2 power to determine whether the guaranteed output has been achieved.

C. Runaway Speed Test (Optional): Within the guarantee period, the Owner may elect to have a runaway speed test performed on the unit to confirm that the guarantee with respect to runaway speed has been fulfilled. If such test is undertaken, it will be performed at the highest head available at the time of the tests, with no load on the generator and with the wicket gates fully open giving the highest runaway speed. The test will be of not more than one minute duration from the time the maximum speed has been attained.

D. The Equipment Supplier shall demonstrate that wicket gates close in unison and that sealing surfaces make contact.

E. Test Reports: A complete report (or reports) of the field tests performed on the equipment, including initial operation and performance tests shall be furnished. The report shall include a description of the items tested and of the instrumentation; a list of test personnel; calibrations of measuring equipment; test procedures; tabulations of measurements taken; sample calculations; test results, including final adjustments, settings, and turbine performance curves; and a discussion of the test results and conclusions.

3.05 INSTRUCTION

Instruction shall be as specified in Section 01730. Instruction manual shall be project specific, a generic manual is not acceptable.

END OF SECTION

SECTION 15970
TURBINE GOVERNOR

PART 1 - General

1.01 DESCRIPTON

A. Requirements for designing, manufacturing, shop testing, providing technical supervision and certification of installation, and field testing including, but not limited to, the following in connection with a new turbine governor for the Pine Flat Unit 4 Addition.

1. Solid-state digital electronic governor system with PLC based controller including redundant power supplies, CPU, memory (ROM and RAM), I/O modules and communication modules for integration with the powerhouse automation system.
2. Servomotors.
3. Redundant speed sensing transmitters for sensing turbine speed.
4. Wicket gate position transmitters.
5. Shop tests and inspections.
6. Governor field testing.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. Refer to Spec. Section 11510, Valve Operator and Hydraulic Power Unit.

B. International Electrotechnical Commission (IEC)

IEC 308	International Code for Testing of Speed Governing Systems for Hydraulic Turbines

C. American National Standards Institute, Inc. (ANSI)

ANSI/IEEE Std 125	Preparation of Equipment Specifications for Speed Governing of Hydraulic Turbines Intended to Drive Electric Generators
ANSI B93.81M	Hydraulic Fluid Power - Positive Displacement Pumps and Motors - Dimensions and Identification Code for Mounting Flanges and Shaft Ends - Two- and Four-Hole Flanges and Shaft Ends - Metric Series

D. American Society of Mechanical Engineers (ASME)

ASME PTC 29	Speed Governing Systems for Hydraulic Turbine-Generator Units

ASME Division 1	Section 8

E. American Society for Testing and Materials (ASTM)

ASTM D 4174	Standard Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems

F. American Society of Nondestructive Testing (ASNT)

SNT-TC-1A	Recommended Practices, Nondestructive Testing

G. Institute of Electrical and Electronics Engineers (IEEE)

IEEE 472	Guide for Surge Withstand Capability (SWC) Tests

H. National Electrical Manufacturer's Association (NEMA)

1.03 SUBMITTALS

A. Submittals shall conform to the requirements of Section 01300.

B. Submit material lists, material certificates, catalog data sheets, product specifications and descriptive literature, and performance data for items provided.

C. Submit detailed step-by-step procedures and drawings for site unloading, handling, storage and maintenance, field assembly, installation, check out, startup, testing and commissioning of all equipment to be furnished.

D. Submit Shop Drawings:

1. General:

    a. Before proceeding with manufacture of the governor system, Equipment Supplier shall submit general assembly drawings, subassembly drawings, detail drawings, calculations, engineering data, catalog sheets, and similar engineering documents required to demonstrate fully that all parts will conform to the provisions and intent of this Section, and to the requirements related to installation, operation, and maintenance. Drawings shall show all necessary dimensions and fabrication details, including the type and grade of materials, details of welded and bolted joint connections, tolerances on fits and clearances, nondestructive examinations, and all field joints.

2. Detail Drawings:

    a. Arrangement drawings for the governor system shall be furnished. Drawings shall be fully dimensioned and shall indicate locations for all devices. Drawing legends shall be furnished to identify all components.

    b. General arrangement drawings of the turbine interfacing with servomotors and governor.

c. Drawings showing clearances, pertinent dimensions, weights, etc.

d. Details of servomotor assembly and individual servomotor components.

e. Detailed arrangement of combined governor and TSV hydraulic power unit, piping arrangement drawings interconnecting HPU, wicket gate servomotors, accumulator bank, and TSV servomotor.

f. Hydraulic schematic, including descriptions of component functions and legends.

g. Installation details for all level transmitters, gate position transmitters, speed transmitters, pressure switches, level switches, flow switches and temperature switches. Shall include, as a minimum, installation drawings for:

   (1) Wicket gate position switches and transmitters.

   (2) Turbine speed sensing transmitters.

h. Governor control system block diagrams and descriptive text detailing operation of the governor system. All modes of operation shall be covered including, but not limited to, start, stop, synchronizing, loading, unloading, automatic and manual operation, emergency stop, black start, alarms, etc.

i. PLC program details shall be submitted for the Engineer’s review. PLC programming for the system PLC shall be reviewed and approved by the Engineer before being implemented by the Equipment Supplier. The programming shall be fully annotated with sufficient information for determining operation of the system.

j. The Human Machine Interface terminal (HMI) screen arrangements shall be submitted for Owner review. Development of the various monitoring and control screens shall be a joint effort between the Owner and the Supplier. Supplier shall include an allowance for at least three (3) design reviews at various development stages (e.g. 50%, 75%, 100%) to finalize the control system monitoring points, control parameters, and HMI screen arrangements. Additionally the suppliers shall include an allowance for a field demonstration of the control screens with the Owner prior to the Factory Acceptance Test.

k. Hydraulic control schematic and electrical schematic and interconnection diagrams for the governor system detailing the hydraulic control system and interconnection of the PLC with all external control and monitoring devices. Drawing legends shall be furnished to identify all components and wiring.

l. Schematics and wiring diagrams for control systems showing all component interconnections for control, monitoring, and protective circuits.

m. Catalog data sheets of all system components and any other drawings needed to clarify or document the design.

n. All drawings marked with equipment tag numbers shall be in accordance with a numbering system approved by the Owner.

E. Submit Engineering Data.

1. Calculations, engineering data, analyses of the following:

a. Servomotor force calculations.

b. Pressure drop calculations in hydraulic circuit interconnecting the various hydraulically operated equipment.

c. Governor oil specifications.

F. Submit Quality Assurance/Control Submittals.

1. Nondestructive Examination (NDE) Program including procedures and specifications.

2. Shop Test Program.

3. Shop Test Report including pertinent records of tests, measurements, and inspections made during fabrication.

4. Installation Instructions.

5. Cleaning and Flushing Procedures.

6. Field Testing Procedures.

7. Field Test Reports including pertinent records of field tests, measurements, and inspections made during installation and testing.

8. Operation and maintenance manuals in accordance with Section 01300.

1.04 DESCRIPTION OF WORK

A. Governor shall be a fully functional digital electronic governor system, designed to seamlessly control wicket gate position in conjunction with the TSV and HPU operation as specified in their respective sections.

B. Coordinate with sections 11510, 15645, 15980, 16310.

C. The governor supply and related turbine work shall be complete with all parts and components specified and/or required for operation, installation, and maintenance including items and devices not specifically called for in these Specifications but necessary to provide a complete and operational system and to stabilize operation, reduce excessive noise or harmful vibration, or otherwise provide satisfactory operation of the turbine.

D. Furnish special handling equipment and other support equipment, if required, for installation, which are specific to the Supplier's design and which cannot be readily purchased.

E. Furnish specified spare parts in accordance with this Section.

F. Furnish one complete set of erection and maintenance tools needed for the adjustment and normal maintenance of the equipment. The set of tools shall be neatly mounted in heavy-duty steel cabinets provided with locks and suitable for wall mounting. Tools shall be clearly identified as to intended use.

G. Furnish one complete set of erection supplies, including nuts and bolts, electrodes, grouting material, alignment-checking instruments, and templates needed for efficient installation of the equipment and for checking the installed equipment.

H. Furnish all equipment and accessories for handling the supplied equipment including sets of slings and other accessories to form and handle bundles during transportation and for unloading at the job site. Various supplied equipment shall also include all supporting elements for transportation.

1.05 DESIGN PARAMETERS

A. The principal design parameters for the governor are as follows:

B. Nominal Working Pressure: 1,000 psi. Actual working pressure to be determined by Equipment Supplier.

   1. Design Pressure: 1,000 psi.

1.06 DESIGN CRITERIA

A. General.

   1. Drawings and reference drawings indicate a conceptual general arrangement for the turbine-generator unit and powerhouse, maximum overall dimensions, and other pertinent features. Equipment Supplier shall furnish detailed designs in conformance with these Specifications and provide a governor that fits within the proposed powerhouse.

   2. All aspects that are not specified in this Section shall be in accordance with the recommendations of applicable industry design standards, and with conservative design practice.

   3. Design criteria used for the governor shall ensure that all operations can be performed as specified over 50-years of service life with minimal inspection and maintenance and can safely operate under the loading and operating conditions specified herein and in other related Sections of these Specifications.

   4. Design governor and related Work to operate safely, reliably, and smoothly without binding, vibration, excessive cavitation, noise, or heat.

5. Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock.

6. Stress concentration factors shall be used where applicable.

B. Provide a coordinated and adequate design fulfilling the requirements of these Specifications.

C. Equipment Supplier shall be responsible for using safety factors throughout the design of the equipment specified herein.

D. Allowable Stresses: Equipment Supplier shall be responsible for an adequate design based on factors proven in practice and shall use lower working stresses whenever deemed necessary or desirable.

E. Piping.

1. Piping shall conform to the requirements of ASME B31.1. The piping size shall be selected so that there is negligible pressure loss between the power unit reservoir and the servomotors. All flexible connections including hoses shall be of the same nominal size as the rigid piping.

2. Fluid flow velocity in all parts of the system shall be limited to 15 ft/s for pressure lines and 4 ft/s for suction lines and return lines to the reservoir and head tank.

1.07 DESCRIPTION AND FUNCTION

A. General.

1. The governor control system shall be a new microprocessor-based control system. The hydraulic actuating components shall be interfaced with programmable logic controller (PLC) control components. The PLCs shall be interfaced with the Master control system specified in Division 16310, “Turbine and Generator Control Switchboard.

2. The governor shall control, in a stable manner, the speed of the turbine at all power outputs between zero and maximum when the generating unit is operating either isolated or in parallel with the system.

3. The governor shall have the capability for starting and stopping, synchronizing, and loading and unloading the turbine manually.

4. The governor shall interface with the TSV controls.

5. The governor shall include the necessary speed sensing elements, hydraulic control circuits, restoring mechanisms, speed switches, position switches, transducers and other required accessories to make a complete operating unit capable of controlling and regulating the turbine.

6. The governor shall sense the speed of the turbine rotation, generate a signal proportional to the difference between the turbine speed and the governor speed reference, then develop a hydraulic control signal of sufficient power to regulate

the wicket gate servomotors to control the hydraulic turbine in accordance with the IEEE Standard 125, latest revision, unless otherwise stated in this specification.

7. The governor PLC control unit shall be housed in the Control Switchboard (Specification Section 16310), separate from the hydraulic components.

8. The governor shall be furnished with an automatic locking feature that will cause the turbine control mechanism to lock at its last position in the event of speed sensor failure, power failure, or operation of other protective devices. The locking feature shall permit the turbine control servomotors to close under action of the servomotor limit and automatic shutdown devices.

B. Governor Features

1. The governor system shall be furnished with the following features:

   a. Speed Changer - The speed changer shall cause the governor to vary the speed or power output of the turbine within the limits specified herein. The speed changer shall be suitable for synchronizing the generator for parallel operation with the electrical grid. The speed change shall be initiated by switches located at the governor cabinet. The setting of the speed changer shall be indicated by a dial or digital display, at the Control Switchboard, calibrated in percent of rated speed.

   b. Wicket Gate Limit - A wicket gate limit shall be provided to establish the maximum allowable position of the servomotor, and shall be adjustable from zero to full servomotor stroke. The wicket gate limit shall be initiated by switches located at the governor cabinet. The setting of the wicket gate limit and the wicket gate position shall be indicated by a dial or digital display, at the Control Switchboard, calibrated in percent of servomotor stroke.

   c. Speed Droop - A speed droop adjustment shall be furnished at the governor to adjust the permanent speed droop as specified herein. The speed droop setting shall be indicated by a dial, or digital display, at the Control Switchboard, calibrated in percent.

   d. Wicket Gate Servomotor Velocity Adjustment - Both the opening and closing wicket gate servomotor velocities shall be independently adjustable. The method of adjustment shall be such that operation of any control, automatic, or auxiliary device cannot cause the turbine wicket gate servomotors to move at a velocity greater than that set by the adjustments.

   e. Manual Control - The governor shall have means for manually controlling the turbine wicket gate position. A suitable transfer device shall be provided at the governor so that the change from governor to manual control can be made in a bumpless manner and without the possibility of releasing the wicket gates from automatic simultaneously. Manual wicket gate position controls shall be located at the Control Switchboard. Indicating lights shall show which control mechanism is in operation.

   f. Automatic Shutdown - The governor shall cause automatic closure of the turbine wicket gate control servomotors on occurrence of specified actions or system limits. The devices shall cause either partial shutdown to speed-no-load or complete shutdown upon contact closure input.

g. Emergency Shutdown - Emergency pushbutton shutdown control shall be located at the Control Switchboard.

h. Wicket Gate Lock - An automatic servomotor lock control shall be furnished to automatically lock the servomotors in the fully closed position when the turbine is shutdown. The lock shall automatically release upon unit start initiation. Manual control of the wicket gate lock shall also be furnished.

i. Creep Detection - Creep detection shall be furnished to trigger an alarm and energize a relay output. The system shall be capable of detecting a 3-degree rotation of the generator shaft.

j. Automatic Control - Provisions shall be made for integrating the governor into the system turbine-generator automatic starting and stopping controls.

k. As a minimum, the following indication shall be furnished at the Control Switchboard, and shall also be available at all automation system HMI terminals:

(1) Speed setting position, 0 – 100%

(2) Wicket Gate limit setting, 0 – 100%

(3) Wicket Gate position, 0 – 100%

(4) Turbine speed, rpm

(5) Speed droop setting, percent

(6) “Governor – Manual” mode of operation

(7) “Governor – Automatic” mode of operation

(8) Governor oil pressure

(9) HPU sump oil level

2. As a minimum, the following status and alarm indication shall be furnished at the Control Switchboard, and shall also be available at all automation system HMI terminals:

a. Low oil level

b. High oil level

c. High oil temperature

d. Low oil pressure

e. High oil pressure

f. Oil pump failure

g. PLC failure

h. Speed sensing failure

i. Turbine creep

j. Overspeed

C. Performance

1. The governor shall control the turbine without hunting at any speed from 85-percent of rated speed, at no load and zero speed droop, to 105-percent of rated speed at rated load and maximum speed droop.

2. The governor system shall be capable of controlling, in a smooth and continuous manner, the speed of the turbine at all power inputs between zero and maximum whether the generating unit is operating isolated or in parallel with the electrical grid. The governor shall be considered stable if:

   a. The steady-state governing speed band of the generating unit does not exceed +/-0.3% of rated speed with the unit at 5-percent speed droop and operating at rated speed, with either no-load or isolated sustained load conditions.

   b. The steady-state governing speed band of the generating unit does not exceed +/-0.4% of rated speed with the unit at 5-percent speed droop and operating at rated speed, with the unit connected to the electrical grid.

3. The speed dead band, at rated speed, shall not exceed 0.02% at any gate opening.

4. The dead time of the governor shall not exceed 0.2-seconds for a step load change of 10% or more of the capacity of the turbine.

5. Speed control shall cover the range from 85% of rated speed, at no load and zero speed droop, to 105% of rated speed at maximum servomotor position and maximum speed droop.

6. The proportional, integral and derivative (PID) gains of the control system shall be independently adjustable with ranges that permit stable control of the governed system.

7. Speed droop shall be capable of adjustment from zero to ten percent when the speed adjustment is set to give rated speed with full servomotor stroke.

D. The governor shall facilitate synchronizing over the range of 85% to 105% of rated speed and shall be adaptable for automatic synchronizing and automatic load or frequency control.

E. The speed signal to the governor shall vary directly with the speed of the main shaft of the turbine at all rates of acceleration and deceleration. The signal shall not be affected by variations in the voltage or current of the main generator or exciter or of the power system to which the main generator is connected. Vibration or normal lateral movement of the turbine shaft shall not affect the fidelity of the speed signal.

F. Wicket gate position feedback to the governor shall be furnished. Digitally encoded output transmitters shall furnish position information to the governor.

1.08 QUALITY ASSURANCE

A. Perform Work in accordance with applicable requirements or recommendations of IEC, ANSI/IEEE ASME, NEMA, ASTM, and other reference codes.

B. The Owner and Engineer may desire to inspect or witness various stages of the Work.

C. Certify that personnel performing Non-Destructive Testing (NDT) examinations have been qualified as Level II Examiners (at a minimum) in accordance with American Society of Nondestructive Testing, Recommended Practice, SNT-TC-1A.

D. Certify that personnel performing welding have been qualified in accordance with ASME Code Section IX.

1.09 QUALIFICATIONS

A. The Work shall be carried out by a company regularly engaged in the design, manufacturer, service, and repair of digital electronic governors and associated hydraulic power systems. Equipment Supplier shall have specific design and manufacturing experience with governors of approximately the same size, type, and complexity of that specified and required.

B. Installer of the governing systems and related Work, whether the Supplier itself or a Subcontractor, shall be currently in the business of installing governors for hydraulic turbines. Installer shall have specific experience with turbine governors of approximately the same size, type, and complexity of that specified and required. Installer shall be subject to approval of the Engineer.

C. Welding: Qualification of welders and welding operators shall conform to the requirements of ASME, Division 1, Section IX.

1.10 WARRANTY

Warranty the governor, materials, and equipment in accordance with Section 01750.

1.11 OPERATION AND MAINTENANCE

Submit complete sets of O&M manuals in accordance with Section 01300.

1.12 SUBSTITUTES

Equipment Supplier shall submit written requests for material and equipment substitutions, for review and approval of Engineer.

1.13 MANUFACTURER’S FIELD SERVICE REPRESENTATIVE

Equipment Supplier shall furnish a qualified and experienced manufacturer’s field service representative that is fluent in written and spoken English to oversee installation, certify installation, and perform startup and commissioning tests.

1.14 NOTICES AND CERTIFICATES

A. Submit the following notices and certificates:

1. “Notice of Start of Manufacturing.”

2. “Notice of Shipment.”

3. At completion of the installation, but prior to startup testing, “Manufacturer’s Certificate of Compliance.” Confirming that the installation is in accordance with manufacturer’s requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish devices, hydraulic parts, and accessories necessary to furnish and install one Horizontal Francis turbine with a fully functional digital electronic governor.

B. Furnish devices, hydraulic parts, and accessories necessary to furnish and install one Horizontal Francis turbine governing system hydraulic power unit and servomotors.

C. Furnish control systems with equipment and features for local and remote control of unit from Control Switchboard.

D. Furnish components for governing system within a single assembly ready for installation and operation. Arrange to provide easy access for adjustment and maintenance of equipment. Furnish baseplates, anchor bolts and other necessary materials for securing cabinets to the powerhouse floor.

2.02 ELECTRONIC GOVERNOR SYSTEM

A. Programmable Logic Controller (PLC)

1. The PLC controller shall be a modular type unit with processor; power supply, communication modules, and I/O mounted in a multiple slot chassis. The PLC shall be an Allen-Bradley ControlLogix system, or equal..

2. The PLC processor shall be furnished with sufficient memory; speed; and math and PID instruction sets to meet the specified turbine and generator control and monitoring performance criteria. The processor shall utilize IEC 1131-3 compliant programming languages. The processor shall have an operating temperature range of 0º to +60ºC. The processor shall be an Allen-Bradley ControlLogix5000 series. A single PLC on the Control Switchboard shall be used for the overall unit control, including unit governor.

3. The processor shall be equipped with battery-backed static RAM memory modules.

4. The processor shall support multi-tasking operations permitting multiple control tasks to operate independently within the same processor.

5. The PLC processor chassis and any required remote I/O chassis shall be furnished with adequately sized power supplies. The power supplies shall be rated for 24 volt dc, input with sufficient dc output to power all PLC processor and I/O requirements. The power supplies shall have an operating temperature range of 0º to +60ºC. The power supplies shall be powered from dc to dc power supplies powered from the station battery. The power supplies shall be Allen-Bradley Type 1756.

6. The PLC shall be furnished with the proper input and output (I/O) modules for interfacing with the required external mechanical and electrical sensing devices. The I/O voltage, current, and isolation requirements shall match that of the external sensing devices. The I/O modules shall have an operating temperature range of 0º to +60ºC. I/O modules shall be Allen-Bradley Type 1756. I/O modules shall include but not be limited to:

   a. Discrete input and output modules for interfacing with ac, dc and Transistor-Transistor Logic (TTL) voltage levels. Modules shall be of 16-point density for ac voltage applications and 32-point high density for TTL voltage levels. Relay contact modules shall be used for 125 vdc applications.

   b. Analog input and output modules shall be high resolution, 16-bit for input modules and 14-bit for output modules. Modules shall be set up for 4-20 mA operation.

   c. The high-speed counter input module, for turbine speed sensing, shall accept input pulse frequencies from the proximity switch. The module shall be able to provide rate measurement up to 20 kHz over an adjustable rate period range from 10-milliseconds to 2-seconds.

7. The PLC shall be furnished with the required communication modules for communicating with the Ethernet system and the various remote I/O devices. The communication modules shall be Allen-Bradley or approved Allen-Bradley third party manufacturer.

B. Speed Signal Device

1. The governor shall be furnished with a speed signal device sensing rotational speed of the generator shaft. The system described herein is a toothed wheel/proximity switch type speed signal device; other speed signal means of proven design may be considered, subject to the Engineer's review and

approval. The range and accuracy of the speed sensor shall be compatible with the governor performance requirements.

2. A steel toothed wheel, or pole band, with a minimum of 120 teeth, shall be furnished and attached to the generator shaft for activating the speed sensing proximity switch. The shaft speed shall be sensed by counting the wheel teeth with the PLC high-speed counter module. The proximity switch shall have zero – sensing capability with a frequency range of 0 – 8 kHz. The sensors shall be Electromatic Check-Line Model DJ2G or “approved” equal.

3. Dual redundant speed sensors shall be furnished for the toothed wheel, or pole band.

C. Position Sensors

1. Position sensing transmitters shall be furnished to indicate the position of the wicket gate servomotor.

2. The servomotor position sensing transducers shall be of the non-contact magnetic linear displacement type. The transducers shall be furnished with anodized aluminum body, stainless cast flange, and 316 stainless steel tube. The transducers shall be furnished with SSI (synchronous serial interface) output for interfacing with the PLC. The transducers shall have a resolution of 1 μm. The transducers shall be Balluff Micropulse, or “approved” equal.

D. Enclosure

1. The governor control components shall be installed in the Turbine-Generator Control Switchboard (refer to Specification Section 16310).

2. Steel work shall be thoroughly cleaned after all welding, drilling and punching has been completed. The cleaning process shall be immediately followed with a rust inhibiting priming coat. The mounting panels and the inside surface of the governor PLC control panel shall be given a gloss white finish. The outside surface of the control panel shall be finished ANSI 61 light gray.

E. Nameplates

1. Furnish nameplates for instruments, relays, control switches, push buttons, indicating lights, and other items where the circuit and function of the device cannot be otherwise readily determined.

2. Nameplates shall be made of white plastic cut through to a black background. The lettering shall be of a size and design such that it will be legible from reasonable angles of observation and from distances of at least 10 feet.

3. Nameplates shall be screw-retained type.

F. Control Wiring

1. The governor PLC control cabinet and HPU assembly shall be completely wired, and wires for connections to remote equipment shall be brought to terminal blocks. All wiring shall be neat and workmanlike, without splices and with a uniform arrangement of circuits. Wire bundles or single wires shall run in straight lines with 90-degree corners, where change of direction is required.

2. All control wire, inside of panels, shall be #18 AWG or larger. Wiring shall be UL type, SIS or MTW, flexible stranded copper, control wire.

3. Where possible wiring shall be run in plastic wire duct with covers. Where it is not possible to contain the wiring in the duct, the wiring shall be wrapped with plastic spiral binding. The plastic wire duct and spiral binding shall be as manufactured by the Panduit Company, Hoffman or “approved” equal.

4. Wire bundles crossing hinges shall be securely clamped to both the door and the panel, and run parallel to the hinge for at least half the door length to prevent chafing. No splicing shall be permitted in the wire duct or spiral wrapped wire bundles.

5. The wires connecting the various devices to each other and terminal blocks shall be labeled at both ends with destination codes. Wire labels shall be white heat shrink polyolefin sleeves with black lettering. Wire labels shall be Floy Tag & Manufacturing, Inc. Type FT-200S, or “approved” equal.

6. Terminal blocks for control wiring shall be molded type, with barriers, rated not less than 300 volts, 25 amperes, suitable for conductors ranging between No. 22 and No. 14. White marking strips shall be provided with function codes (abbreviations indication function of the terminal point). Each connected terminal of each block shall have a function code placed on the marking strip with permanent marking fluid. Terminal blocks shall be Entrelec Type M 6/8.STP, or “approved” equal.

7. Terminal blocks for control power terminations shall be fused type with indicator. Fused terminal blocks shall be Entrelec Type MB 10/22.SFL with 13/32”x 1-1/2” fuse, or “approved” equal.

G. Pushbuttons

1. All pushbuttons shall be round, oiltight, heavy-duty type units. Pushbuttons shall be Allen-Bradley Type 800T, Cutler-Hammer, Square D Class 9001 Type K or “approved” equal.

2. The pushbutton legend plates shall be engraved as shown on the “approved” Equipment Supplier Drawings.

H. Switches

1. All control and instrument switches shall be of the rotary switchboard type with handles on the front and the operating mechanisms on the rear of the panel. Contacts of all switches shall be self-aligning and shall operate with wiping action. A positive means of maintaining high pressure on closed contacts shall

be provided. The rear switch covers or plates shall be readily removable for inspection of contacts. Switches shall be Electro Switch Type 24, or “approved” equal.

2. The switch legend plates shall be engraved as shown on the “approved” Equipment Supplier Drawings.

I. Indicating Lights

1. Indicating lamp assemblies shall be LED assemblies of the switchboard type, suitable for 125-vdc service, with appropriate color caps and integrally mounted resistors. The LED lamps shall be replaceable from the front of the panel. All color caps shall be interchangeable, and all LED lamps shall be of the same type and rating. The lamp assemblies shall be GE Type ET-16-LED or “approved” equal.

2. The lamp legend plates shall be engraved as shown on the “approved” Equipment Supplier Drawings.

J. Auxiliary Relays

1. Auxiliary control relays shall be vibration and shock resistant industrial type relays, and shall be rated for operation at 125 vdc, as required. Convertible type contact blocks rated for 125 vdc operation shall be furnished. Auxiliary relays shall be Allen-Bradley 700 Type N or “approved” equal.

2. Auxiliary control relays used for 120 vac or 24 vdc control shall be vibration and shock resistant industrial type relays, and shall be rated for operation at 120 V ac or 24 V dc, as required. Auxiliary relays shall be Potter & Brumfield Type KUP, or equal.

K. Power Supplies

1. The power supplies for 24 vdc requirements shall be switching type power supplies. The power supplies shall be rated for 105 to 145 volts dc input and 24 volts dc, output with +/-1% load regulation from 10% load to full load. The power supplies shall be Absopulse Electronics Ltd., or “approved” equal.

L. Indicating Displays

1. The discrete digital indicating displays shall be 6-digit LED units. The display shall be 0.56-inch, 6-digit, 7-segment, red LED type. The display and associated electronic drives shall be housed in a black, thermoplastic, front panel mount case. The displays shall be Red Lion Controls Model IMP, or “approved” equal.

M. Operator Interface Terminal (OIT)

1. The OIT on the Turbine-Generator Control Switchboard shall be used for monitoring the governor PLC.

2. The OIT screens shall be arranged to indicate the specified monitoring information and controls. The final arrangement of the required screens shall be

as approved by the Engineer. Refer to Section 01200 for meetings to be attended by Equipment Supplier during development of the OIT screens.

N. Fuses

1. The PLC and indicating devices shall be fused with 13/32 x 1-1/2-inch dual-element type fuses. Fuses shall be Buss Fusetron Type FNM or “approved” equal.

2.03 ELECTROHYDRAULIC INTERFACE

A. Provide an electrohydraulic interface, including all necessary adapter plates and hydraulic piping. The electrohydraulic interface shall include the following functional elements mounted on a single manifold.

1. Proportional Valve: Electrohydraulic type valve to convert the control system output to a hydraulic output that controls wicket gate servomotor actuator position.

2. Shuttle Valve: Hydraulic type valve mounted on a manifold directly below the proportional valve. The shuttle valve will be slaved to the shutdown valve and block flow from the proportional valve during emergency conditions.

3. Emergency Shutdown Valve: Solenoid-operated valve to override the output of the proportional valve by shifting the shuttle valve to block flow from the proportional valve and port oil directly to the closing side of the gate servomotor.

4. Manual Shutdown Valve: Manually operated valve to provide an independent means of forcing the servomotor to the fully closed position.

2.04 PIPING

A. General.

1. Piping in the power unit shall be completely installed in the shop before shop testing and shipping.

2. Manual vent valves shall be provided at all high points and wherever else required in the system for the complete removal of trapped air. The valves shall have threaded female ends and shall be of corrosion-resistant steel or bronze. The outlet ports of all vent valves shall be plugged with threaded bronze plugs.

3. Piping in the power unit shall be laid out such that it shall not obstruct access to, or removal of, hydraulic components for maintenance or inspection.

B. Pipe shall be seamless stainless-steel conforming to ASME B36.19M and ASTM A 312, Grade TP304L. The piping weight class shall be Schedule 80. The pipe shall conform to the cleanliness requirements of ANSI B93.11.

C. Pipe Fittings.

1. Pipe fittings shall be made of stainless-steel conforming to ASTM A 182, Grade F304L. The pressure class shall be 3000 psi.

2. Threaded fittings shall conform to ASME B16.5, but shall be used only where absolutely necessary for the application. Threaded fittings shall be of the straight thread, O-ring, SAE type connections.

D. Unions shall be the O-ring type, made of stainless steel with socket-welding ends. The Equipment Supplier may at his option substitute four bolt split flanges with Buna N O-rings for the unions.

E. Tubing shall be seamless stainless steel tubing conforming to ASTM A 789. The wall thickness shall be selected to provide a safety factor of 6 based on the manufacturer's ratings for burst strength.

F. Tube fittings shall be made of stainless steel and be the flareless type with SAE straight threads and Buna N O-ring seals. The fittings shall conform to SAE J514.

G. Hose: Flexible hydraulic hoses, if required, shall be SAE 100R12 4 spiral (medium wire) rubber hose, such as style CE rubber hose as manufactured by the Dayco Corporation, Dayton, OH 45401, or equal. Minimum burst pressure shall be 15,000 psi. Flexible hose shall be rated by the manufacturer for a working pressure not lower than 3000 psi with a factor of safety of 4. Rubber or synthetic rubber shall be selected for maximum compatibility with the hydraulic fluid specified for use in the system. Fittings shall be stainless steel and shall be specifically designed for use with the hose selected shall be equivalently rated and shall be as recommended by the hose manufacturer.

H. Hydraulic Valves – General.

1. Valves shall have a minimum pressure rating of 3000 psi unless stated otherwise. Valves shall be of standard manufacture and nominally rated for zero leakage. Valves shall be specifically designed and rated for hydraulic system applications.

2. Valves 1 inch or larger shall have socket-welded piping connections. Valves less than 1 inch shall have SAE straight thread ends and Buna N O-rings.

3. Pressure-relief and flow-control valves shall be preset in the shop to their operational setting. Electrically operated valves shall be furnished with suitable provisions for standby manual operation.

4. Each valve shall be furnished with a corrosion-resistant tag suitably engraved or stamped to identify the valve according to its designation on the hydraulic circuit drawing and according to its function in the system.

5. Control valves shall be subplate mounted for socket-welded connections. Control valves shall have steel housings, unless otherwise noted or specified. The valves shall be pressure-compensated, free flowing in one direction, and

adjustable. The valves shall be capable of being locked in position to prevent an unintentional adjustment.

6. Solenoid valves shall be UL-listed.

7. Ball Valves (Shutoff Valves): Ball valves shall be made of stainless steel with socket welded connections. The valves shall have replaceable seats and be repairable without disturbing the welded connections.

8. Needle Valves: Needle valves shall be made of stainless steel and designed for fine flow regulation and adjusting the operating speed of the I/O gates. The stem sealing O-rings shall be Buna N.

9. Three-way Valves: Three-way valves shall be pilot-operated, solenoid-controlled, two-position control valves for operating the valve operator. The valve will operate only to lower or close the valve. The valve shall be subplate mounted with socket-welded piping connections. The solenoids shall operate at 120 volts AC.

10. Pressure Relief Valves: Pressure relief valves shall be adjustable, pilot type with an internal drain. Pressure relief valves shall be for maintaining maximum system pressure within 5% of the preset value.

11. Unloading Valves: Unloading valves shall be adjustable and designed for minimum 3000 psi service. The pressure setting and the flow capacity shall be determined by the Contractor so that the valve operates without cavitating.

12. Spring Loaded Check Valves: Spring loaded check valves shall be of stainless-steel construction and shall be the ball or poppet type with a body designed for high shock and 3000 psi service. Furnish check valves on each pump discharge to prevent backflow through pump. Check valves shall be spring-loaded for closure with minimum shock. Pilot-operated check valves shall be provided where the check valve has to open against pressure.

13. Counterbalance Valve

    a. A counterbalance valve shall be installed in the oil line to the bottom side of the hydraulic cylinder to balance the load being held by the cylinder. The valve shall be pilot-operated, adjustable pressure setting, spring return, with internal bypass valve for reverse free-flow. The valve shall permit unrestrained flow to the underside of the cylinder piston and shall function to retain pressure in the cylinder in the amount of the valve’s pressure adjustment.

    b. Porting and operation of valve:

        (1) Raising (opening) valve: valve shall open in a free-flow direction allowing free-flow out of the three-way valve and into the TSV cylinder.

        (2) Lowering (closing) valve: valve shall unseat when internal pilot pressure is sufficient and provide progressive opening of the valve along with dampening orifice for smooth operation.

14. Bleeder Valves (Air Vent Valves): Bleeder valves shall be 1/4 inch, globe valves, stainless steel construction. Air bleed valves shall be located at local high spots throughout the piping system and at each piping connection to the TSV operating cylinder.

15. Pressure Snubbers: Pressure snubbers shall be provided for all pressure gauges and pressure switches to protect against shock and provide more stable instrument operation. Snubbers shall be of stainless steel construction.

I. Pipe supports such as pipe hangers, anchors, guides, clamps, etc. shall conform to the applicable requirements of ANSI B31.1.

J. Field Piping: Furnish all piping between HPU and servomotors. There shall be no discernible movement of hydraulic oil lines as wicket gates and valves are operated. Securely clamp hydraulic lines at intervals no greater than 4 ft.

K. Hydraulic Fluid: The hydraulic fluid to be used during shop testing, to fill the cylinders before shipment, flush the system after installation, and to fill the complete hydraulic system shall be an all-weather type hydraulic oil which has a high viscosity index, low pour point, rust and oxidation inhibitors, and antifoam properties. The oil shall also be biodegradable and non-toxic. Fresh hydraulic fluid shall be filtered through a 10-micron filter before it is added to the system. All oil shall be supplied by the Equipment Supplier, and shall be a common manufacturer, type, and grade for all valve hydraulic power systems, governing systems, and generators, ISO grade VG-46.

2.05 SERVOMOTORS

A. Servomotors: Pressure-operated, double-acting, hydraulic cylinder type for operating wicket gates. Oil for operating servomotor(s) supplied under pressure from HPU. Furnish servomotor(s) as follows:

1. Drain valves and piping for draining oil from each end of servomotor cylinder and for bleeding entrapped air and for test pressure gauge connections.

2. Adjustable slow-closing or cushioning device for retarding the rate of closing travel between the approximate speed-no-load position for average head and the closed position.

3. Manually adjustable stroke-limiting device that can be locked to positively limit maximum gate opening position.

4. Position transmitter.

5. Indicating Scale: Scale with pointer to accurately indicate gate opening.

6. Oil pressure connections to servomotor(s) constructed of rigid piping connected to flexible hoses on servomotor.

7. Servomotors to be equipped with quick-connect test ports.

B. Capacity: Sufficient to operate turbine and TSV, under all conditions of head and load, through the full servomotor opening and closing stroke at minimum oil pressure.

C. Linkages: Design, detail, procure, and fabricate all necessary linkages, pins, fasteners, etc. to connect servomotor to turbine gate operating ring . All bushings and bearings shall be self-lubricating.

2.06 SHOP TESTS, INSPECTIONS, AND VERIFICATIONS

A. General.

1. The governor and hydraulic power unit shall be completely assembled, inspected, and tested in the shop, unless otherwise approved, to assure satisfactory field installation and operation in compliance with these Specifications. Adjoining components shall be fitted and bolted together to ensure proper fit during field erection and assembly. Assembled components shall be shop-welded in their final positions as much as delivery and field installation conditions will permit.

2. It will be permissible for the governor control cabinet to be tested separately from the hydraulic power unit. If the control cabinet and hydraulic unit are manufactured in separate facilities then they may be independently tested prior to shipment. The required input and output signals shall be simulated for the system tests.

3. Required repairs or replacements to correct defects, as determined by the Supplier and the Engineer, shall be made at no additional cost to the Owner. Testing shall be repeated after defects and deficiencies have been corrected.

4. Prior to major shop assemblies and tests, submit Equipment Supplier’s Shop Test Program outlining procedures and tests planned to demonstrate fulfillment of the requirements of this Section.

5. All shop assemblies and tests specified will be witnesses by the Engineer, and the Engineer and the Supplier shall sign completed shop inspection forms. Copies of all shop inspection records shall be furnished to the Engineer. No equipment shall be shipped from the Supplier’s shops until it has been inspected.

6. Extreme care shall be taken during shop assembly to avoid inclusion of foreign materials into the equipment. The interior of the piping shall be cleaned with lint free cloths and flushed with oil at a minimum velocity of 15 fps, which has passed through a 10-micron filter. The cleaning procedure shall be in accordance with ASTM D4174. The piping and valves shall be sealed with enough oil in the system to protect the metal surfaces.

B. Perform shop assembly prior to shipment to verify design, construction, and machining for proper alignment, fits, and clearances.

C. Tests.

1. Shop leakage test.

a. The oil reservoir shall be tested for leaks by means of dye penetrant.

b. The servomotor piston seals shall be tested for leakage. Any leakage past the piston seals shall be cause for rejection.

2. Shop pressure tests: Pressure test components and devices subject to oil pressure at 1.5 times the design maximum operating pressure. Hold pressure for 30 minutes. No leakage permitted. Repair and retest all leaks. After testing, thoroughly clean equipment and piping of any liquids that may cause corrosive action.

3. Shop operating tests: After successful completion of shop pressure and leakage tests, the governor equipment shall undergo a functional test. Perform mechanical, electrical, and functional shop tests on governor, power unit, and servomotors. The equipment shall be functionally tested to the extent practicable to demonstrate proper operation and sequence of controls. Tests shall include mock testing using simulated remote controls. Pressure relief and other control valves shall be checked and adjusted as required. Adjust and calibrate gauges, switches, and meters.

D. Shop Test Report.

1. Following final shop inspections of the equipment, submit pertinent records of tests, measurements, and inspections, including a detailed tabulation showing values of measurements and all adjustments recorded during the tests.

2.07 SPARE PARTS

A. Spare parts: Interchangeable with and identical to corresponding parts of the governor systems, HPU, and servomotors furnished under this Contract.

B. Furnish one spare rod, plunger, and bushing assembly for each type and size of governor valve.

C. Furnish one spare pump/motor assembly.

D. Furnish three spare sets of all O-rings, seals, packing, and gaskets.

E. Furnish one spare set of solenoid coils of each type and rating.

F. Furnish three spare sets of all lamps, bulbs, and fuses.

G. Furnish three spare sets of filters and strainers.

H. Include a list of spare parts with sufficient descriptive information to allow the part to be identified in the field.

PART 3 - EXECUTION

3.01 PREPARATION

A. Installation of equipment as specified herein, as shown on the Drawings, and in accordance with "approved" Shop Drawings, instructions, and procedures will be performed under a separate Construction Contract. Equipment Supplier to provide detailed installation instructions as well as the services of an on-site Field Service Representative, as indicated in the Bid Form.

3.02 INSTALLATION

A. General:

1. Establish sequence of operations and methodology for installing equipment in conformance with requirements set forth in the Specifications.

2. Become familiar with the problems involved with the installation and with the fact that certain erection and installation operations will require levels of accuracy and reiterative inspection procedures that exceed ordinary practices in construction.

3. Furnish Field Service Representative supervision, tools, supplies, bracing, spiders, shims, supports, lubricants, oils, and other material necessary to assemble, erect, install, test, and make the equipment operational.

B. Installation:

1. Exercise care when handling all parts or subassemblies, particularly to ensure that the machined surfaces are not damaged or otherwise flawed.

2. Install equipment in accordance with installation procedures developed by the Equipment Supplier and “approved” by the Engineer.

3. Adjust and align equipment to achieve the alignment tolerances of the assembled equipment in strict conformance with the Equipment Supplier's requirements.

C. Position Transducers

1. The wicket gate position transducers shall be installed in accordance with the “approved” Equipment Supplier Drawings. Stainless steel hardware shall be used for attaching the transducer operating assembly to the wicket gate operating mechanisms.

D. Speed Signal Device

1. The steel toothed wheel, or pole band, and speed sensing proximity switches shall be installed on the generator shaft in accordance with the “approved” Supplier Drawings.

E. Installation Certification

1. At completion of installation, Equipment Supplier’s Field Service Representative shall submit to the Engineer a Letter of Certification, certifying that the installation has been made in compliance with the Equipment Supplier’s instructions and indicating that the system is ready for testing.

3.03 CLEANING AND FLUSHING

A. Equipment Supplier shall submit a detailed cleaning and flushing procedure for approval as specified herein. Before installation of hydraulic power unit, cylinders and manifolds, all hydraulic field piping shall be flushed. Bypass loops of piping shall be installed in place of cylinders, manifolds, and the power unit. Equipment Supplier’s Field Service Representative shall supervise the cleaning and flushing procedures.

B. Clean and flush the system in accordance with approved procedures, the requirements set forth in ASTM D4174, and the equipment manufacturer’s written instructions using hot, low-viscosity flushing oil and successively finer filters. Hydraulic oil must be circulated through each and every pipe until returning oil meets NAS 1638, Class 8 requirements. The flushing fluid shall be compatible with the hydraulic working fluid. Installation Contractor shall legally dispose of flushing oil and filters off-site at an approved disposal site. When flushing is completed, the system shall be drained and then filled with the specified hydraulic fluid.

C. Filling and Bleeding the System: Oil used to fill the system shall be filtered through a 10-micron filter. The complete hydraulic power system shall be bled to remove all air from the system. Care shall be taken to exclude as much air as possible during initial filling.

3.04 QUALITY CONTROL

A. Supply test instruments and equipment. Use test equipment that is certified as calibrated prior to testing. Supply the calibration curves available for test evaluation.

B. Check equipment for proper installation and adjustment, including gauges, instruments, controls, flow indicators and switches, valves, strainers, pumps, etc. prior to testing. Calibrate all gauges, switches, instruments, and similar devices and provide Engineer copies of calibration records.

C. Installation Checks and Testing:

1. General: The installation checks and testing specified herein may be augmented if deemed advisable by the Equipment Supplier’s Field Service Representative. Improper operation or poor condition of safety devices, electrical components, mechanical equipment, and structural assemblies shall be monitored during testing. Defects observed to be critical during the testing period shall be reported immediately to the Engineer and the testing operations shall be suspended until the defects are corrected. The following requirements are specified hereafter to establish the minimum extent of checks and testing required.

2. Field Pressure Test: Hydrostatically test components and devices subject to oil pressure at a pressure 50% greater than the design maximum operating pressure. Hold pressure for 30 minutes. No leakage permitted. Repair and retest any leaks. After testing, thoroughly clean equipment and piping of any liquids that may cause corrosive action.

3. Prepare and submit for approval Supplier's Field Test Procedures for testing, startup, and commissioning the governor system. Perform the following checks and tests:

   a. Adjust wicket gates for uniform closure and gate "squeeze set."

   b. Measure and record wicket gate opening versus servomotor position at 10 uniform increments over full wicket gate stroke to establish the relationship of any point between servomotor stroke and gate opening. Determine that portion of the stroke that is required to obtain "squeeze set."

   c. Check pressure tap piping for obstructions and proper functioning.

   d. Check gauges, instruments, controls, valves, lubricating devices, flow indicators, filters, pumps, etc.

   e. Calibrate gauges, instruments, controls, temperature devices, meters, indicators, level transmitters, and associated electrical and mechanical devices.

   f. Perform a 24-hour pre-test on oil pumps and piping to ensure satisfactory performance.

   g. Perform operation tests on relays, indicators, thermostats, speed switches, resistant temperature detectors, and flow switches to verify correct calibration, adjustment, and operational readiness.

   h. Inspect governor and other equipment to be certain that all foreign matter has been removed.

   i. Check field wiring to verify conformance with Shop Drawings and schematic wiring diagrams; to ensure proper phasing and polarity of all power conductors; and to confirm that cable shields are grounded only at the points indicated.

   j. Check electrical controls by trial operation of control equipment after wiring is completed to ensure that each interlock and control function operates according to the connection diagrams, as well as in accordance with the manufacturer's schematics and operating instructions.

   k. Check for proper stopping. All safety devices including emergency stop switches shall be tested and inspected to verify proper operation of control devices.

   l. Check for abnormal noise or vibration and overheating in equipment furnished.

m. Check for proper travel and operation, freedom of movement, and abnormal noise or vibration.

n. Check electrical drive components for proper operation, freedom of chatter, noise, and overheating.

o. Inspect for abnormal wear, damage, or inadequate lubrication.

4. Adjustments and Repairs: Equipment Supplier shall perform adjustments and repairs until satisfactory conditions are maintained at no additional cost to the Owner. Adjust travel limiters, switches, controls, and other devices as required. After adjustments have been made to ensure correct functioning, appropriate testing shall be repeated.

3.05 START-UP AND INITIAL OPERATION

A. Provide qualified and experienced personnel to perform operating functions during start-up and initial operation. The Owner's operating staff will participate in performing operating functions during start-up and initial operation under Supplier's direction.

B. Perform the following tests and correct items identified as being defective or requiring adjustment.

C. Performance test governor in accordance with IEC 308.

D. Initial No-Load Run: Perform no-load run per Section 15645.

E. Initial Load Run: After approval from the Engineer, synchronize and connect unit to the electrical system. Perform initial load run per Section 15645.

F. Perform load rejection tests per Section 15645.

1. Make any adjustments to governor system at each load rejection test before proceeding with the next test.

2. Test and adjust automatic start/stop control sequencing and operation.

3. Test and adjust unit controls and/or unit output controls and remote controls for proper operation.

3.06 TEST REPORT

A. Submit a complete report of field testing performed on the governor equipment, including initial operation and performance tests. Include a description of items tested and instruments; a list of test personnel; calibration of measuring equipment; test procedures; tabulations of measurements; sample calculations; test results, including final adjustments and settings; and a discussion of the test results and conclusion.

END OF SECTION

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SECTION 15980
UNIT 4 – HPU (HYDRAULIC POWER UNIT)

PART 1 - General

1.01 DESCRIPTION

A. Requirements for designing, manufacturing, shop testing, providing technical supervision and certification of installation, and field testing including, but not limited to, the following in connection with a new HPU for the Pine Flat Unit 4 Addition.

1. Hydraulic power unit (HPU) for Turbine Shutoff Valve (TSV) and turbine governor operation.
2. Sump tank.
3. Accumulators.
4. Shop tests and inspections.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. This section shall be coordinated with:

1. Spec. Section 11510, Valve Operator
2. Spec. Section 17970 Turbine Governor

B. American National Standards Institute, Inc. (ANSI)

ANSI B93.81M	Hydraulic Fluid Power - Positive Displacement Pumps and Motors - Dimensions and Identification Code for Mounting Flanges and Shaft Ends - Two- and Four-Hole Flanges and Shaft Ends - Metric Series

C. American Society of Mechanical Engineers (ASME)

ASME Division 1	Section 8

D. American Society for Testing and Materials (ASTM)

ASTM D 4174	Standard Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems

E. American Society of Nondestructive Testing (ASNT)

SNT-TC-1A	Recommended Practices, Nondestructive Testing

F. Institute of Electrical and Electronics Engineers (IEEE)

IEEE 472	Guide for Surge Withstand Capability (SWC) Tests

G. National Electrical Manufacturer's Association (NEMA)

1.03 SUBMITTALS

A. Submittals shall conform to the requirements of Section 01300.

B. Submit material lists, material certificates, catalog data sheets, product specifications and descriptive literature, and performance data for items provided.

C. Submit detailed step-by-step procedures and drawings for site unloading, handling, storage and maintenance, field assembly, installation, check out, startup, testing and commissioning of all equipment to be furnished.

D. Submit Shop Drawings:

1. General:

a. Before proceeding with manufacture of the HPU, Equipment Supplier shall submit general assembly drawings, subassembly drawings, detail drawings, calculations, engineering data, catalog sheets, and similar engineering documents required to demonstrate fully that all parts will conform to the provisions and intent of this Section, and to the requirements related to installation, operation, and maintenance. Drawings shall show all necessary dimensions and fabrication details, including the type and grade of materials, details of welded and bolted joint connections, tolerances on fits and clearances, nondestructive examinations, and all field joints.

2. Detail Drawings:

a. Arrangement drawings for the HPU shall be furnished. Drawings shall be fully dimensioned and shall indicate locations for all devices. Drawing legends shall be furnished to identify all components.

b. Drawings showing clearances, pertinent dimensions, weights, etc.

c. Details of hydraulic power unit.

d. Hydraulic schematic, including descriptions of component functions and legends.

e. Details of accumulators.

f. Details of hydraulic piping, including routing details.

g. Catalog data sheets of all system components and any other drawings needed to clarify or document the design.

E. Submit Engineering Data.

1. Calculations, engineering data, analyses of the following:

a. Hydraulic pump capacities.

b. Motor power calculations.

c. Accumulator capacity calculations

d. Pressure drop calculations in hydraulic circuit.

e. Oil specifications.

F. Submit Quality Assurance/Control Submittals.

1. Nondestructive Examination (NDE) Program including procedures and specifications.

2. Shop Test Program.

3. Shop Test Report including pertinent records of tests, measurements, and inspections made during fabrication.

4. Installation Instructions.

5. Cleaning and Flushing Procedures.

6. Field Testing Procedures.

7. Field Test Reports including pertinent records of field tests, measurements, and inspections made during installation and testing.

8. Operation and maintenance manuals in accordance with Section 01300.

1.04 DESCRIPTION OF WORK

A. Work includes design and supply of hydraulic power unit, accessories, and appurtenant piping, manifolds, and valves necessary to hydraulically operate all equipment as required for complete remote operation of the unit.

B. The hydraulic power unit shall be designed to operate the TSV servomotor and governor servomotors according to the operating conditions provided.

1.05 DESIGN PARAMETERS

A. The principal design parameters for the HPU are as follows:

B. Nominal Working Pressure: 1,000 psi. Actual working pressure to be determined by Equipment Supplier.

1. Sound Rating: 85-dBA maximum at 3 ft.

1.06 DESIGN CRITERIA

A. All aspects that are not specified in this Section shall be in accordance with the recommendations of applicable industry design standards, and with conservative design practice.

B. The design criteria used for the HPU shall ensure that all operations can be performed as specified over 50-years of service life with minimal inspection and maintenance and can safely operate under the loading and operating conditions specified herein and in other related Sections of these Specifications.

C. General.

1. Preliminary design drawings indicate a conceptual general arrangement for the turbine-generator unit and powerhouse, maximum overall dimensions, and other pertinent features. Equipment Supplier shall furnish detailed designs in conformance with these Specifications and provide an HPU that fits within the proposed powerhouse.

2. The HPU shall be designed to provide high pressure control oil to the TSV and the turbine wicket gate servomotor.

3. Pump Ratings: Each pump shall have capacity sufficient to operate the TSV actuator cylinder at the rated speed and at a discharge pressure equal to the nominal system design pressure.

4. Reservoir Volume: Useful volume (between highest and lowest working level) of the hydraulic fluid reservoir shall not be less than 150% of the active fluid volume (piston rod displacement volume plus volume in connecting piping).

5. Accumulator capacity for emergency storage shall be sufficient to provide 3 full strokes of the valve operator at or above minimum pressure to close the valve under worst-case conditions without using the pumps. Design the system to maintain required capacity for at least 4 hours after loss of AC power.

6. All aspects that are not specified in this Section shall be in accordance with the recommendations of applicable industry design standards, and with conservative design practice.

7. Design criteria used for the HPU shall ensure that all operations can be performed as specified over 50-years of service life with minimal inspection and maintenance and can safely operate under the loading and operating conditions specified herein and in other related Sections of these Specifications.

8. Design HPU and related Work to operate safely, reliably, and smoothly without excessive vibration, noise, or heat.

9. Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock.

10. Fluid Temperature:

    a. Minimum fluid temperature shall be the same as the minimum ambient temperature. Maximum fluid temperature shall be limited to 130°F.

    b. Hydraulic fluid shall be assumed to have the least favorable temperature between minimum and maximum temperatures when verifying the rated operator capacity and speed of operation.

c. Tolerance for operating speed: Specified valve opening and closing speed shall not vary more than 10% between the maximum and minimum ambient temperature.

11. Speed Changes: Shutting of ports for speed changes shall be progressive so that the peak value of valve deceleration during closing shall not be greater than 1 ft/s^2, except in case of rupture of operator piping when deceleration shall not be greater than 5 ft/s^2.

D. Hydraulic Oil

1. For ease of stocking the oil, the governor and TSV hydraulic oil type shall be identical to the existing three units. The existing unit governor HPUs use **Shell Turbo T68** oil.

E. Equipment Supplier shall be responsible for using safety factors throughout the design of the equipment specified herein.

F. Allowable Stresses: Equipment Supplier shall be responsible for an adequate design based on factors proven in practice and shall use lower working stresses whenever deemed necessary or desirable.

G. Piping.

1. Piping shall conform to the requirements of ASME B31.1. The piping size shall be selected so that there is negligible pressure loss between the power unit components . All flexible connections including hoses shall be of the same nominal size as the rigid piping.

2. Fluid flow velocity in all parts of the system shall be limited to 15 ft/s for pressure lines and 4 ft/s for suction lines and return lines to the reservoir and head tank.

H. To prevent galvanic corrosion, non-metallic insulators shall be used between dissimilar metals.

1.07 TSV OPERATING CONDITIONS

A. The hydraulic power unit shall be designed for the following TSV operating conditions.

1. Normal Operation:

a. Continuous operation with the Turbine Shutoff Valve in the open position passing normal turbine flows under normal head.

b. Gravity closure of the Turbine Shutoff Valve against maximum turbine discharge, maximum head according to turbine manufacturer design.

c. Valve in closed position withstanding maximum static head of 159.0 ft.

2. Emergency Operation:

   a. Gravity closure of the Turbine Shutoff Valve using an operator and/or counterweighted lever arm against maximum penstock flow as provided by turbine manufacturer during runaway condition.

1.08 TSV OPERATING REQUIREMENTS

A. Operating Modes: The Turbine Shutoff Valve shall be designed for manual and auto control modes in both remote or local operations. Design HPU to incorporate valves and instrumentation necessary for the following requirements.

B. Manual Control

   1. Manual Bypass: A mechanical-hydraulic valve shall be provided with the hydraulic power unit to close the valve manually without electrical power and bypassing all electrical interlocks.

C. Pump Operation

   1. Furnish pump controls for the two main pumps with one pump for normal operation and one pump as a jockey pump for drift control and backup pump operation.

      a. Main Pump No. 1: Provided for operating the valve during normal operation with the pump selector switch in the “Pump No. 1 lead” position.

      b. Main Pump No. 2: Provided for operating the valve during normal operation with the pump selector switch in the “Pump No. 2 lead” position.

      c. Jockey Pump (Pump No. 3): Provided for drift control of the Turbine Shutoff Valve during normal operation.

   2. When the pump lead-lag selector switch is in the “Pump No. 1” position the pump “Ready” indicating light for Pump No. 1 shall be illuminated and the indicating light for Pump No. 2 shall be off. When the pump selector switch is in the “Pump No. 2” position the pump “Ready” indicating light for Pump No. 2 shall be illuminated and the indicating light for Pump No. 1 shall be off.

   3. The hydraulic power unit pump motors shall automatically shutoff in case of pump failure, low-low oil level in the reservoir, and thermal overload.

   4. Provide pump status signals, indicating lights, run timers, start and stop pushbuttons, and local and remote selector switch.

D. Temperature Switch: To signal low oil temperature and illuminate the “Low Oil Temp” indicating light.

E. Control switches, indicating lights, and digital readouts shall be provided as specified below.

   1. Level Switches: To signal low and low-low oil level in reservoir. When the low oil level setpoint is reached the “Low Oil Level” indicating light shall be illuminated. When the low-low oil level setpoint is reached the “Low Oil Level” indicating light shall be illuminated and the pumps shall be tripped and shutdown.

2. Filter Switches: To signal when differential pressure across any filter reaches a predetermined setting and illuminate the “Check Filter” indicating light.

3. Power: The “Power” indicating light shall illuminate when power is on at the hydraulic power unit. The light shall go off when power is interrupted.

4. Hydraulic System Pressure: The “System Pressure” digital readout shall be interconnected to the pressure transmitter providing a 4-20 mA signal corresponding to hydraulic system pressure.

1.09 QUALITY ASSURANCE

A. Perform Work in accordance with applicable requirements or recommendations of IEC, ANSI/IEEE ASME, NEMA, ASTM, and other reference codes.

B. The Owner and Engineer may desire to inspect or witness various stages of the Work.

C. Certify that personnel performing Non-Destructive Testing (NDT) examinations have been qualified as Level II Examiners (at a minimum) in accordance with American Society of Nondestructive Testing, Recommended Practice, SNT-TC-1A.

D. Certify that personnel performing welding have been qualified in accordance with ASME Code Section IX.

1.10 QUALIFICATIONS

A. The Work shall be carried out by a company regularly engaged in the design, manufacturer, service, and repair of hydraulic power systems. Equipment Supplier shall have specific design and manufacturing experience with hydraulic power systems of approximately the same size, type, and complexity of that specified and required.

B. Welding: Qualification of welders and welding operators shall conform to the requirements of ASME, Division 1, Section IX.

1.11 WARRANTY

Warranty the governor, materials, and equipment in accordance with Section 01750.

1.12 OPERATION AND MAINTENANCE

Submit complete sets of O&M manuals in accordance with Sections 11050 and 01300.

1.13 SUBSTITUTES

Equipment Supplier shall submit written requests for material and equipment substitutions, for review and approval of Engineer.

1.14 MANUFACTURER'S FIELD SERVICE REPRESENTATIVE

Equipment Supplier shall furnish a qualified and experienced manufacturer's field service representative that is fluent in written and spoken English to oversee installation, certify installation, and perform startup and commissioning tests.

1.15 NOTICES AND CERTIFICATES

A. Submit the following notices and certificates:

1. "Notice of Start of Manufacturing."

2. "Notice of Shipment."

3. At completion of the installation, but prior to startup testing, "Manufacturer's Certificate of Compliance." Confirming that the installation is in accordance with manufacturer's requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Unless specified otherwise material and workmanship requirements for fabrication of the HPU and appurtenances shall be according to section 05000 Materials and Workmanship.

B. Furnish devices, hydraulic parts, and accessories necessary to furnish and install one HPU System including pumps, control valves, and valve manifolds for supplying oil to wicket gate servomotors, TSV servomotor, and other hydraulic valves according to the turbine-generator's design.

C. Furnish devices, hydraulic parts, and accessories necessary to furnish and install one Horizontal Francis turbine governing system hydraulic control cabinet.

D. Furnish control systems with equipment and features for local and remote control of unit from Control Switchboard.

E. Furnish components for governing system within a single assembly ready for installation and operation. Arrange to provide easy access for adjustment and maintenance of equipment. Furnish baseplates, anchor bolts and other necessary materials for securing cabinets to the powerhouse floor.

2.02 GOVERNOR ELECTROHYDRAULIC INTERFACE

A. Provide an electrohydraulic interface, including all necessary adapter plates and hydraulic piping. The electrohydraulic interface shall include the following functional elements mounted on a single manifold.

1. Proportional Valve: Electrohydraulic type valve to convert the control system output to a hydraulic output that controls wicket gate servomotor actuator position.

2. Shuttle Valve: Hydraulic type valve mounted on a manifold directly below the proportional valve. The shuttle valve will be slaved to the shutdown valve and block flow from the proportional valve during emergency conditions.

3. Emergency Shutdown Valve: Solenoid-operated valve to override the output of the proportional valve by shifting the shuttle valve to block flow from the proportional valve and port oil directly to the closing side of the gate servomotor.

4. Manual Shutdown Valve: Manually operated valve to provide an independent means of forcing the servomotor to the fully closed position.

2.03 HYDRAULIC POWER UNIT (HPU)

A. General.

1. Refer to Section 11510, TSV Operator.

2. HPU shall be a self-contained, packaged unit designed to operate the turbine servomotors and the TSV as specified. The power unit shall be designed to meet the space limitations of the proposed powerhouse and arrangement of equipment.

3. Adjustments for pressure and temperature switches, valves, pressure relief valves and other devices shall be readily accessible. Oil filters shall be located for easy removal of the filter element. The unit shall be provided with all required hydraulic and electrical devices, system valves, alarms, protective relays, etc. to guarantee reliable and safe operation.

4. Select all components and devices to minimize oil leakage. The hydraulic power unit shall be furnished with test connections at appropriate locations for attaching a pressure gauge or transducer.

B. Oil Pumps:

1. Main Pumps: Two duplicate/identical, motor-driven, self-priming, variable-displacement vane type; vertically in-tank mounted or mounted on shock-mounted rails. Pump/motor acoustically isolated.

2. Main Pump Capacity: Each pump shall have a capacity not less than 25% of the combined individual servomotor/actuator volumes divided by the respective minimum servomotor/actuator and TSV closure times, and any appurtenances.

3. Lead/Lag Pump Operation: Furnish pumps with one main pump as the lead pump and the lag pump as the standby. Provide lead/lag selector switch so either main pump may be selected as the lead pump.

    a. Lead Pump: Provide for normal system leakage and closing and opening of wicket gate servomotors during normal operation. Provide lead pump failure alarm.

    b. Lag Pump: To start if the lead pump is unable to maintain system pressure during unusual or emergency operating conditions. Provide lag pump with adjustable time to alarm on excessive lag pump run time.

4. Jockey Pump: One motor-driven, self-priming, variable-displacement vane type, sized to provide make-up oil for system leakage, plus 25% capacity.

5. Auxiliary Filter Pump: the HPU shall be equipped with a kidney loop system for regular filtering of the hydraulic system oil.

6. Pump Control: Constant pressure control by jockey pump running continuously, and lead main pump and lag main pump operating based on pressure and flow demand. Flow proportional to displacement by adjusting swashplate position to maintain a constant pressure in hydraulic system.

7. Pressure Switches: Adjustable from circuit opening to circuit closing, supplied with pressure snubbers for the following settings:

    a. High-Pressure: Shutdown Trip.

    b. High-Pressure: Alarm.

    c. Low-Pressure: Lead Pump Start.

    d. Low-Pressure: Lag Pump Start.

    e. Low-Pressure: Alarm.

    f. Low-Pressure: Shutdown Trip.

8. Pressure Transducer: Transducer to provide analog signal for pressures from zero to 1,500 psi. Design pressure for transducer is 2,500 psi.

9. Isolation and Check Valves: Furnish ball valves to isolate each pump so that it may be removed without shutting down the pressure system. Furnish isolation ball valves equipped with limit switches to lock out respective pump motor. Furnish each pump discharge with a check valve to prevent back flow through pump.

10. Pressure-Relief Valve: Provide on the discharge side of each pump (routed back to oil reservoir) to prevent system damage due to over-pressurization.

11. Motors: Continuously rated, NEMA Design B, TEFC, Class B temperature rise, with Class F insulation, and a 1.15 service factor. Equip motors with grease-lubricated, anti-friction type thrust and guide bearings, and designed for direct coupling to pump shaft. Provide sealed type insulation using non-hygroscopic materials unaffected by moisture or petroleum products.

12. Motor Starters: Motor starters shall include electromechanical contactor with solid-state type overload relay. The starters shall be designed for full voltage starting of 3-phase squirrel cage motors and conform to NEMA standards. Starters shall be sized to conform to NEMA sizes 0–5 as required by the application. All starters shall be UL listed. Starters shall be Allen-Bradley Type 509 with SMP-1 overload relay, or equal.

C. Oil Reservoir:

1. Sump Tank: Heavy gage, steel fabrication conforming to the requirements of ANSI B93.18M. Deck and sidewalls provided with machined surfaces, as required, to accommodate accessories. The sump tank shall be a heavy gage steel fabrication of adequate thickness and rigidity to prevent excessive vibration and noise. Reservoir provided with shoulder-width access, built-in drip tray, lifting lugs, and anchoring features, as required. Provide internal baffle between suction and return lines. Arrange valving, piping, and other devices on standardized segmented valve panels or bar manifolds.

2. Temperature Switches: Equip reservoir with temperature switches for the following settings:

   a. High Oil Temperature: Alarm.

   b. High Oil Temperature: Shutdown Trip.

3. Oil Level Sight Gauge: Equip reservoir with oil level sight gauge. Scribe oil level switch settings on gauge.

4. Level Switches: Equip reservoir with oil level switches for the following settings:

   a. High Oil Level: Alarm.

   b. Low Oil Level: Alarm.

   c. Low/Low Oil Level: Shutdown Trip.

   d. Low/Low Oil Level: Stop Lead Pump.

   e. Low/Low Oil Level: Stop Lag Pump.

5. Reservoir Heater: Provide with one or more screw plug type immersion heaters with a watt density suitable for the intended use and a built-in thermostat set to maintain the hydraulic oil at 60ºF based on a minimum ambient temperature of 40°F. The heater sheath and screw plug shall be fabricated from stainless steel.

6. Magnetic Separators: Provide the manufacturer's standard magnetic separator in the reservoir. The magnetic separator shall consist of a high-strength permanent magnet arranged for rigid mounting with the poles of the magnet exposed to the fluid in the reservoir. The magnet shall be incorporated in the bottom drain plug. The drain plug type installation shall incorporate a valve arranged to permit removal of the magnetic separator for inspection without loss of fluid from the reservoir.

7. Air Breather: Provide an air breather that removes dirt and moisture from the incoming air. The incoming air shall first pass through a desiccant bed to remove the moisture, and then pass through a filter to eliminate the solid contaminants before entering the reservoir. Outgoing air shall pass directly to the atmosphere through a check valve. The breather shall also provide visual indication of the desiccant and filter condition.

D. Filters.

1. Filters shall be located in the return line to the reservoir and in the pump discharge line. The suction line to the cylinder upper chamber shall not have a filter or strainer. Equip filter with a manually operated 3-way valve to allow changeover from one filter to the other, allowing filters to be changed without shutting down the unit. Equip filter with mechanical clogged filter indicator for local indication and electrical contact for remote indication.

2. Filters shall be of the spin-on type with a bypass and an indicator to show the condition of the filter element. A clogged filter signal and indicating light shall be provided.

3. Filters shall be disposable, replaceable-element type. Elements shall be stainless steel or Monel woven or wound wire. Filters shall be constructed and installed to permit servicing of the filter elements without disturbing the piping and without draining the hydraulic system and oil reservoir. Shutoff valves shall be provided be provided as necessary.

4. Filter Media Rating: Filter elements shall be screw-on type and shall be furnished with the following ratings unless a smaller mesh is recommended by the pump manufacturer:

   a. Pressure filters: 10 microns.

   b. Return filters: 10 microns.

5. Pressure Drop Requirements: The maximum pressure drop across any clean filter at normal flow shall not exceed 5 psi in the normal operating temperature range. The bypass shall be set to open when the pressure drop across the filter element exceeds 15 psi.

E. Gauges.

1. Pressure Gauges: A pressure gauge shall be furnished to indicate system output pressure. Pressure gauges shall conform to ASME B40.1, have a black enameled metal case, 4 1/2 inch dial, and a stainless steel Bourdon tube. The scale range of the gauge shall be approximately 150 percent of the maximum normal operating pressure of the line in which installed. Gauges shall be the safety type with solid fronts and blowout backs. Each gauge shall be provided with a pressure snubber. Gauges and gauge lines shall be bottom tapped in horizontal pressure lines.

2. Temperature Gauges (Thermometer): A direct indicating thermometer shall be provided to indicate fluid temperature in the reservoir. The thermometer shall be of the bimetallic type mounted directly on the reservoir. The thermometer shall have a minimum 3-inch dial with black markings on a white background. The scale range shall be minus 20 to 240^{o}F. The case and stem shall be corrosion resistant, and the wetted components shall be stainless steel. Thermometer wells of the separable socket type shall be provided for each thermometer with a direct type bulb.

3. Accessories: Provide extra return line connection, cleanout and access ports, gated drain connection, and gauge steel guards to protect fragile components such as temperature switches and immersion heaters.

4. Baffle plates shall be provided between the intake and return lines to facilitate the separation of air and foreign matter from the hydraulic fluid. Both the intake and return pipes shall be brought down to a distance of 1 1/2 pipe diameters above the tank bottom.

5. Hydraulic Control Panel: Provide hydraulic control panel mounted on top of the oil reservoir, in the plane of the front face of the reservoir. All hydraulic components, which need to be accessible for manual operation and all gauges, other than those mounted on the governor cabinet, shall be mounted on the hydraulic control panel. All components shall be arranged in an orderly and functional manner, and they shall be removable without removing the surrounding components and piping.

6. Protective Coatings: Prepare and coat interior and exterior surfaces in accordance with manufacturer's standard practices.

   a. Exterior Surfaces:

      (1) Manufacturer's standard coating system.

      (2) Machined surfaces coated with suitable rust preventive.

      (3) Color: Determined during Shop Drawing review and as approved by the Owner.

   b. Interior Surfaces:

      (1) Manufacturer's standard coating system.

      (2) Color: White to enhance inspection and maintenance.

   c. Guard screens and other hazardous components will have a finish coat of safety yellow.

F. Accumulator Assembly:

1. Accumulators: Bladder type, nitrogen charged of standard design for emergency oil pressure and built-in accordance with the requirements for pressure vessels per ASME Section VIII, Division I.

2. Capacity: Supply sufficient capacity of oil to allow 3 full strokes of combined servomotors (turbine wicket gates, plus TSV) under all operating conditions without using the pumps upon emergency low-pressure shutdown. Equipment Supplier shall determine the accumulator capacity and low-pressure shutdown pressure to meet the performance criteria specified herein. Design system to maintain required capacity for at least 4 hours after loss of AC power in powerhouse. Equipment Supplier shall submit calculations showing how accumulator capacity was determined.

3. Mounting Rack: Assemble accumulators on racks and connected together with individual isolation valves and master valve for shut-off and maintenance. Rack to be suitable for mounting to oil reservoir. Provide drip pan with rack.

4. Accessories: Pressure gauge with shut-off valve, gas and oil blow-off valve, and nitrogen pre-charge or pressure alarm.

2.04 PIPING

A. General.

1. Piping in the power unit shall be completely installed in the shop before shop testing and shipping.

2. Manual vent valves shall be provided at all high points and wherever else required in the system for the complete removal of trapped air. The valves shall have threaded female ends and shall be of corrosion-resistant steel or bronze. The outlet ports of all vent valves shall be plugged with threaded bronze plugs.

3. Piping in the power unit shall be laid out such that it shall not obstruct access to, or removal of, hydraulic components for maintenance or inspection.

B. Pipe shall be seamless stainless-steel conforming to ASME B36.19M and ASTM A 312, Grade TP304L. The piping weight class shall be Schedule 80. The pipe shall conform to the cleanliness requirements of ANSI B93.11.

C. Pipe Fittings.

1. Pipe fittings shall be made of stainless-steel conforming to ASTM A 182, Grade F304L. The pressure class shall be 3000 psi.

2. Threaded fittings shall conform to ASME B16.5, but shall be used only where absolutely necessary for the application. Threaded fittings shall be of the straight thread, O-ring, SAE type connections.

D. Unions shall be the O-ring type, made of stainless steel with socket-welding ends. The Equipment Supplier may at his option substitute four bolt split flanges with Buna N O-rings for the unions.

E. Tubing shall be seamless stainless steel tubing conforming to ASTM A 789. The wall thickness shall be selected to provide a safety factor of 6 based on the manufacturer's ratings for burst strength.

F. Tube fittings shall be made of stainless steel and be the flareless type with SAE straight threads and Buna N O-ring seals. The fittings shall conform to SAE J514.

G. Hose: Flexible hydraulic hoses, if required, shall be SAE 100R12 4 spiral (medium wire) rubber hose, such as style CE rubber hose as manufactured by the Dayco Corporation, Dayton, OH 45401, or equal. Minimum burst pressure shall be 15,000 psi. Flexible hose shall be rated by the manufacturer for a working pressure not lower than 3000 psi with a factor of safety of 4. Rubber or synthetic rubber shall be selected for maximum compatibility with the hydraulic fluid specified for use in the system. Fittings shall be stainless steel and shall be specifically designed for use with the hose selected shall be equivalently rated and shall be as recommended by the hose manufacturer.

H. Hydraulic Valves

1. General

   a. Valves shall have a minimum pressure rating of 3000 psi unless stated otherwise. Valves shall be of standard manufacture and nominally rated for zero leakage. Valves shall be specifically designed and rated for hydraulic system applications.

   b. Valves 1 inch or larger shall have socket-welded piping connections. Valves less than 1 inch shall have SAE straight thread ends and Buna N O-rings.

   c. Pressure-relief and flow-control valves shall be preset in the shop to their operational setting. Electrically operated valves shall be furnished with suitable provisions for standby manual operation.

   d. Each valve shall be furnished with a corrosion-resistant tag suitably engraved or stamped to identify the valve according to its designation on the hydraulic circuit drawing and according to its function in the system.

   e. Control valves shall be subplate mounted for socket-welded connections. Control valves shall have steel housings, unless otherwise noted or specified. The valves shall be pressure-compensated, free flowing in one direction, and adjustable. The valves shall be capable of being locked in position to prevent an unintentional adjustment.

   f. Solenoid valves shall be UL-listed.

2. Ball Valves (Shutoff Valves): Ball valves shall be made of stainless steel with socket welded connections. The valves shall have replaceable seats and be repairable without disturbing the welded connections.

3. Needle Valves: Needle valves shall be made of stainless steel and designed for fine flow regulation and adjusting the operating speed of the Turbine Shutoff Valve. The stem sealing O-rings shall be Buna N.

4. Three-way Valves: Three-way valves shall be pilot-operated, solenoid-controlled, two-position control valves for operating the valve operator. The valve will operate only to lower or close the valve. The valve shall be subplate mounted with socket-welded piping connections. The solenoids shall operate at 120 volts AC.

5. Pressure Relief Valves: Pressure relief valves shall be adjustable, pilot type with an internal drain. Pressure relief valves shall be for maintaining maximum system pressure within 5% of the preset value.

6. Unloading Valves: Unloading valves shall be adjustable and designed for minimum 3000 psi service. The pressure setting and the flow capacity shall be determined by the Contractor so that the valve operates without cavitating.

7. Spring Loaded Check Valves: Spring loaded check valves shall be of stainless-steel construction and shall be the ball or poppet type with a body designed for high shock and 3000 psi service. Furnish check valves on each pump discharge to prevent backflow through pump. Check valves shall be spring-loaded for

closure with minimum shock. Pilot-operated check valves shall be provided where the check valve has to open against pressure.

8. Counterbalance Valve

   a. A counterbalance valve shall be installed in the oil line to the bottom side of the hydraulic cylinder to balance the load being held by the cylinder. The valve shall be pilot-operated, adjustable pressure setting, spring return, with internal bypass valve for reverse free-flow. The valve shall permit unrestrained flow to the underside of the cylinder piston and shall function to retain pressure in the cylinder in the amount of the valve's pressure adjustment.

   b. Porting and operation of valve:

      (1) Raising (opening) valve: valve shall open in a free-flow direction allowing free-flow out of the three-way valve and into the TSV cylinder.

      (2) Lowering (closing) valve: valve shall unseat when internal pilot pressure is sufficient and provide progressive opening of the valve along with dampening orifice for smooth operation.

9. Bleeder Valves (Air Vent Valves): Bleeder valves shall be 1/4 inch, globe valves, stainless steel construction. Air bleed valves shall be located at local high spots throughout the piping system and at each piping connection to the TSV operating cylinder.

10. Pressure Snubbers: Pressure snubbers shall be provided for all pressure gauges and pressure switches to protect against shock and provide more stable instrument operation. Snubbers shall be of stainless steel construction.

I. Hydraulic Control Panel: The hydraulic control panel shall be mounted on top of the hydraulic reservoir, in the plane of the front face of the reservoir. All hydraulic components which need to be accessible for manual operation and all gauges, other than those mounted on the local control panel, shall be mounted on the hydraulic control panel. All components shall be arranged in an orderly and functional manner, and they shall be removable without removing the surrounding components and piping.

J. Pipe supports such as pipe hangers, anchors, guides, clamps, etc. shall conform to the applicable requirements of ANSI B31.1.

K. Field Piping: Furnish all piping between HPU and servomotors. There shall be no discernible movement of hydraulic oil lines as wicket gates and valves are operated. Securely clamp hydraulic lines at intervals no greater than 4 ft.

L. Hydraulic Fluid: The hydraulic fluid to be used during shop testing, to fill the cylinders before shipment, flush the system after installation, and to fill the complete hydraulic system shall be an all-weather type hydraulic oil which has a high viscosity index, low pour point, rust and oxidation inhibitors, and antifoam properties. The oil shall also be biodegradable and non-toxic. Fresh hydraulic fluid shall be filtered through a 10-micron filter before it is added to the system. All oil shall be supplied by the Equipment Supplier, and shall be a common manufacturer, type, and grade for all valve hydraulic power systems, governing systems, and generators, **Shell Turbo T68**.

M. Motor Starters

1. Motor starters shall include electromechanical contactor with solid state type overload relay. The starters shall be designed for full voltage starting of 3-phase squirrel cage motors and conform to NEMA standards. Starters shall be sized to conform to NEMA sizes 0–5 as required by the application. All starters shall be UL listed. Starters shall be Allen-Bradley Type 509 with SMP-1 overload relay, or equal.

2.05 PUMP MOTORS

A. The pump motors shall conform to the applicable requirements of NEMA MG 1, except as hereinafter specified, and shall be designed to withstand full voltage starting. The motor shall be of totally enclosed frame construction and shall be fan cooled. A stainless-steel drain-breather similar and equal to Crouse-Hinds type "ECD Universal" shall be provided and located so that any water present can be drained from inside the motor.

1. Rating

   a. The motors shall operate on 480 volts, 60 Hz, 3-phase power and shall be sized to operate the pumps specified in paragraph 2.05.C. The motor shall be designed to operate continuously without exceeding the temperature rise permitted by the applicable NEMA standards for the class of insulation and frame construction used.

2. Winding Insulation

   a. The winding insulation shall be NEMA class F.

3. Winding Heaters

   a. A heater or heaters shall be installed in the motor frame or end bells or wrapped around the winding end turns. The heater shall be manually operated. The heater shall be capable of withstanding the same temperature extremes as the motor. The heater shall be such that when energized the temperature of the motor winding will be held approximately 10 degrees C above ambient. They shall be designed for 120 volts AC continuous operation. Terminals of the heater, including the leads, shall be watertight. The leads shall be terminated in the motor lead terminal box.

4. Terminal Leads

   a. The motor leads shall extend outside the frame, shall have insulation equivalent to that of the motor winding, and shall be terminated in a two-piece, four-position, terminal box secured rigidly to the motor frame. The leads shall be positioned and sealed where they pass through the frame with a water-resistant seal of a synthetic rubber material or else with a synthetic rubber gasket.

2.06 SHOP TESTS, INSPECTIONS, AND VERIFICATIONS

A. Hydraulic Power Unit Tests

1. The hydraulic power unit and control panels shall be shop assembled and inspected for proper fit-up and correctness of principal dimensions. The hydraulic power unit shall be test operated by the Equipment Supplier to demonstrate proper operation and sequence of controls. Tests shall include mock testing using both local and simulated remote controls. Pressure relief and other control valves shall be checked and adjusted as required.

2. For shop pressure and leakage testing, the hydraulic power unit shall be filled with the specified hydraulic fluid filtered to 10 microns, taking care to exclude all air. The tests shall be in accordance with ASME BPVC Section VIII, Division 1.

3. Shop leakage tests: The oil reservoir shall be tested for leaks by means of dye penetrant before assembly of the hydraulic power unit

4. Shop pressure test the hydraulic power unit and piping to the maximum pressure allowed by the installed equipment.

5. Shop operating tests: After successful completion of shop pressure and leakage tests, valves and operators shall undergo a functional test and the pumps shall be tested to verify flow and pressure ratings. The power unit shall then be connected to the hydraulic cylinder and operationally tested. Any operational problems will be cause for rejection. The following tests are specified to establish the minimum extent of checks and testing required.

   a. Moving the operator cylinder in both directions to full stroke at full working pressure at rated speed.

   b. Startup test of motor-driven pumps.

   c. Running test for motor-driven pumps (flow and pressure)

   d. Check of pressure relief valves and pressure settings.

   e. Test of all operation, signaling, and indicating devices.

   f. Test of all valves for both manual and electrical operation

   g. Test of sequence of operation.

6. All the I/O modules in the local control panel shall be tested for proper functioning and all communication and controller programming shall be tested and verified. If possible, the owner prefers integrated testing at the Equipment Supplier's or a third-party shop for a complete control system testing. This is to avoid any potential issues during site testing and start-up.

2.07 Test Reports

A. Prepare and submit shop test reports in accordance with the requirements of this Section.

2.08 SPARE PARTS

A. Spare parts: Interchangeable with and identical to corresponding parts of the governor systems, HPU, and servomotors furnished under this Contract.

B. Furnish one spare rod, plunger, and bushing assembly for each type and size of governor valve.

C. Furnish one spare pump/motor assembly.

D. Furnish three spare sets of all O-rings, seals, packing, and gaskets.

E. Furnish one spare set of solenoid coils of each type and rating.

F. Furnish three spare sets of all lamps, bulbs, and fuses.

G. Furnish three spare sets of filters and strainers.

H. Include a list of spare parts with sufficient descriptive information to allow the part to be identified in the field.

PART 3 - EXECUTION

3.01 PREPARATION

A. Installation of equipment as specified herein, as shown on the Drawings, and in accordance with "approved" Shop Drawings, instructions, and procedures will be performed under a separate Construction Contract. Equipment Supplier to provide detailed installation instructions as well as the services of an on-site Field Service Representative, as indicated in the Bid Form.

3.02 INSTALLATION

A. Installation requirements shall be according to Section 15970 – Turbine Governor.

B. Installation shall be performed as part of a separate contract by others. Installation of all components shall be in accordance with the Equipment Supplier's written instructions and/or drawings under the direction of the Service Department or manufacturer's representative. Necessary supports for interconnecting piping shall be provided under separate contract by installation contractor.

C. Installation Certification

1. At completion of installation, Equipment Supplier's Field Service Representative shall submit to the Engineer a Letter of Certification, certifying that the installation has been made in compliance with the Equipment Supplier's instructions and indicating that the system is ready for testing.

3.03 CLEANING AND FLUSHING

A. Equipment Supplier shall submit a detailed cleaning and flushing procedure for approval as specified herein. Before installation of hydraulic power unit, cylinders and manifolds, all hydraulic field piping shall be flushed. Bypass loops of piping shall be installed in place of cylinders, manifolds, and the power unit. Equipment Supplier's Field Service Representative shall supervise the cleaning and flushing procedures.

B. Clean and flush the system in accordance with approved procedures, the requirements set forth in ASTM D4174, and the equipment manufacturer's written instructions using hot, low-viscosity flushing oil and successively finer filters. Hydraulic oil must be circulated through each and every pipe until returning oil meets NAS 1638, Class 8 requirements. The flushing fluid shall be compatible with the hydraulic working fluid. Installation Contractor shall legally dispose of flushing oil and filters off-site at an approved disposal site. When flushing is completed, the system shall be drained and then filled with the specified hydraulic fluid.

C. Filling and Bleeding the System: Oil used to fill the system shall be filtered through a 10-micron filter. The complete hydraulic power system shall be bled to remove all air from the system. Care shall be taken to exclude as much air as possible during initial filling.

D. Field Operating Tests

1. Initial Checks and Adjustments
    a. Field wiring installed under separate contract after installation and connection to verify conformance with the schematic wiring diagrams to ensure proper phasing and polarity of all power conductors and to confirm that cable shields are grounded only at the points indicated on the Equipment Supplier's Drawings.
    b. Electrical controls by trial operation of control equipment after wiring is completed to ensure that each interlock and control function operates according to the connection diagrams, as well as in accordance with the manufacturer's schematics and operating instructions.
2. Initial Start-Up: The hydraulic reservoir shall be inspected to ensure that the fluid is at the proper level. The accumulator pre-charge pressure shall be inspected and adjusted to the specified value. The hydraulic pumps shall be test started using the controls at the control panel. The pumps shall be inspected for proper rotation and discharge pressure. The discharge pressure of each pump shall be read and recorded. The pressure relief valves shall be adjusted to limit the system pressure to the specified value. The unloading valves shall be adjusted to unload the pumps to the reservoir when the accumulator has been charged to the specified pressure or if the control valves are not actuated. The hydraulic lines and components that are under pressure shall be inspected for evidence of leakage.

3. Combined System Tests: Tests and inspections of the hydraulic power system shall be performed concurrently with the testing specified under Section 11500 – Turbine Shutoff Valve which test the valve and operating mechanism operated by the hydraulic system, and according with the start-up and field testing specified in Section 15300 – Turbine Governor. The hydraulic system shall be tested by operating the turbine shutoff valve through a minimum of four complete cycles. During each test operation, the hydraulic lines and components shall be inspected for evidence of leakage. The pressure in the supply and return lines for each direction of operation shall be read and recorded. Response and sequence of operating controls shall be inspected to verify proper operation. Flow control valves shall be checked and adjusted as required to conform to indicated operating time requirements. Sequence valves shall be inspected and adjusted as required to obtain the indicated sequence of operation. Chokes in pilot circuits of pilot-operated valves shall be adjusted to obtain smooth, shock-free operation.
4. Test Reports: Equipment Supplier shall prepare and complete test reports showing in detail the results of the field tests in accordance with Section 15010 - General Mechanical Requirements.

3.04 QUALITY CONTROL

A. Supply test instruments and equipment. Use test equipment that is certified as calibrated prior to testing. Supply the calibration curves available for test evaluation.

B. Check equipment for proper installation and adjustment, including gauges, instruments, controls, flow indicators and switches, valves, strainers, pumps, etc. prior to testing. Calibrate all gauges, switches, instruments, and similar devices and provide Engineer copies of calibration records.

C. Installation Checks and Testing:

1. General: The installation checks and testing specified herein may be augmented if deemed advisable by the Equipment Supplier’s Field Service Representative. Improper operation or poor condition of safety devices, electrical components, mechanical equipment, and structural assemblies shall be monitored during testing. Defects observed to be critical during the testing period shall be reported immediately to the Engineer and the testing operations shall be suspended until the defects are corrected. The following requirements are specified hereafter to establish the minimum extent of checks and testing required.

2. Field Pressure Test: Hydrostatically test components and devices subject to oil pressure at a pressure 50% greater than the design maximum operating pressure. Hold pressure for 30 minutes. No leakage permitted. Repair and retest any leaks. After testing, thoroughly clean equipment and piping of any liquids that may cause corrosive action.

3. See Section 15970 – Turbine Governor for field testing procedure requirements for the HPU

Adjustments and Repairs: Equipment Supplier shall perform adjustments and repairs until satisfactory conditions are maintained at no additional cost to the Owner. Adjust travel limiters, switches, controls, and other devices as required. After adjustments have been made to ensure correct functioning, appropriate testing shall be repeated.

3.05 START-UP AND INITIAL OPERATION

A. Start-up and initial operation will be performed according to Section 15970 – Turbine Governor.

END OF SECTION

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SECTION 16210
SYNCHRONOUS GENERATOR

PART 1 - GENERAL

1.01 DESCRIPTION

The generator shall be of the horizontal-shaft, hydraulic-turbine driven synchronous type complete with bearings, rotating brushless excitation system, neutral grounding equipment, and a closed system of ventilation with surface air-to-water coolers.

1.02 CODES AND STANDARDS

A. The generator shall comply with the appropriate and applicable codes and standards published by the following organizations:

1. American National Standards Institute (ANSI)
2. National Electrical Manufacturers Association (NEMA)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electric Code (NEC)
5. Insulated Cable Engineering Association (ICEA)

B. The generator shall comply with:

1. ANSI C50.12-2005 – Requirements for Salient Pole Synchronous Generators and Generator/Motors for Hydraulic Turbine Applications Rated 5 MVA and Above.
2. IEEE Standard 1 – General Principles for Temperature Limits in the Rating of Electric Equipment.
3. IEEE Standard 4 – Standard Techniques for High-Voltage Testing.
4. IEEE Standard 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machines.
5. IEEE Standard 115 – Test Procedures for Synchronous Machines.

1.03 SUBMITTALS

A. Submittals required by this section of the Technical Specification shall be submitted for Engineer review in accordance with Section 01300. Submit the following information:

1. Insulation Systems. Submit a description of the stator coil, field coil, and ring bus insulation systems to be utilized, including processes and materials employed to meet specifications requirements.

2. Calculated Electrical Characteristics. Submit a complete list of calculated electrical and mechanical characteristics for the generator. As a minimum submit the following:

   Direct-axis unsaturated synchronous reactance, in pu -Xd

   Quadrature-axis unsaturated synchronous reactance, in pu - Xq.

   Direct-axis transient reactance, in pu - Xd'

   Quadrature-axis transient reactance in pu - Xq'

   Direct-axis subtransient reactance, in pu - Xd".

   Quadrature-axis subtransient reactance, in pu - Xq".

   Negative phase sequence reactance in pu - X2.

   Zero sequence reactance in pu - Xo.

   Potier leakage reactance in pu – X1.

   Direct-axis subtransient open circuit time constant, in sec - Tdo".

   Quad.-axis subtransient open circuit time constant, in sec -Tqo".

   Short circuit ratio.

   Subtransient rms symmetrical 3-phase short-circuit current in pu.

   Total capacitance of one phase of the stator winding to ground.

   Capability curves for both under excited and over excited regions.

   Short circuit saturation curve.

   Open circuit saturation curve.

   Losses for unit at 0.9 pf, and 100%, 75%, 50%, and 25% of full load rating, and 6,900 volts, segregated as follows:

      Armature I^2R at 95ºC*

      Field I^2R at 9ºC*

      Stray load at 95ºC*

      Open circuit core losses

      Friction and windage

Resistance of armature winding at 95ºC**ANSI C50.12-2005 reference temperature.

3. Calculated Mechanical characteristics. Submit stress calculations of stator frame, rotor spider, bearing brackets, and shafts to document and verify that components will meet the maximum stress levels and minimum design life specified herein.

4. Core Construction. Submit a complete description of the stator core materials, stacking procedure, and tolerances.

5. Core Clamping. Submit a complete description of the core clamping system to be utilized.

6. Assembly Materials. Submit a complete description of materials for the assembly of the stator winding including all wedging, filler, insulation, and bracing materials.

7. Resistance Temperature Devices (RTDs). Submit a complete description of the RTDs to be installed in the windings and stator core.

8. Stator Cooling System Design. Submit detailed specifications for the air-to-water heat exchangers and the cooling water piping.

9. Electrical load list detailing all power requirements for the generator and auxiliary systems.

10. Detailed step-by-step procedures and drawings for site unloading, handling, storage and maintenance, field assembly, installation, check out, startup, testing and commissioning of all equipment to be furnished.
11. Certified Material and Test Reports.
12. Material standards that differ from those specified.
13. Material standards for materials not specified.
14. Casting documents including casting process, working drawings, inspection, test, and repair procedures, and reports.
15. Illustrations showing location, depth and length of defects in the castings and the repair methods prior to starting repairs.
16. Forging documents including forging process, working drawings, inspection, test, and repair procedures, and reports

B. Drawings

1. General arrangement drawing of combined turbine-generator assembly.

2. Cross-sectional drawing of combined turbine-generator assembly, with main components identified.

3. Generator Outline and Assembly Drawings. Submit detail drawings of the generator assembly and individual major components showing dimensions, materials, weights and anchoring requirements. Drawings of foundation anchoring and bearing plate assemblies, cooler assemblies, bearing assemblies, collector ring assembly, support bracket assemblies, generator enclosure, brake system, rotor assembly including pole and winding details, etc. Drawings shall clearly indicate access to all required maintenance and

inspection areas including but not limited to brake cylinders, bearings, wiring terminals, etc.

4. Cross-sectional drawing of generator, showing the internal arrangement of parts, working clearances, oil levels and other details.

5. General arrangement drawings of oil head piping mounted on the generator and routed in hydraulic power unit and governor. General arrangement drawings of bearing oil piping mounted on the generator and routed to external oil coolers.

6. Lifting and handling diagrams. Include component weights and lift points.

7. Load diagrams showing forces and loads transferred from generator to supporting concrete foundations.

8. Stator Winding Assembly Drawings. Submit plan and section views detailing the stator winding assembly for the generator. Details shall show stator coil strand arrangement, strand dimensions, copper cross-sectional area, strand and conductor insulation, insulation materials, insulation thickness and wedging. Overall winding assembly drawings will show dimensions of the stator circuit ring configurations, and bracing configurations.

9. Winding Diagram. Submit overall winding diagram for the generator.

10. Winding Ancillary Details. Submit layout drawing showing proposed location of RTDs and vibration sensors. Submit details of Partial Discharge Analysis (PDA) system components within the generators showing their locations, cable routing, coupling capacitor, installation, and termination panel.

11. Fabrication and machining details of stator and rotor assemblies, generator shaft, guide bearings, thrust bearing, lifting devices and other major parts including all materials and any options.

12. Details of coolers, embedded parts and miscellaneous structural and mechanical parts.

13. Details of terminal boxes and gauge panels.

14. P&IDs.

15. Hydraulic and cooling water schematics.

16. Electrical wiring diagrams and interconnects for generator, instrumentation and auxiliaries.

17. Piping and conduit drawings for all auxiliary systems.

18. All drawings marked with equipment tag numbers shall be in accordance with a numbering system approved by the Owner.

C. Procedures and Instructions

1. Manufacturing process plan (MPP).
2. Inspection and test plan (ITP) – for shop and field work.
3. Welding procedures specifications (WPS).
4. Procedure qualification records (PQRs) supporting WPSs
5. Welder performance qualification records.
6. Post weld heat treatment and stress relief procedures.
7. Nondestructive examination (NDE) procedures.
8. Shop assembly and factory test procedures with checksheets.
9. Installation drawings, procedures and checksheets.
10. Field testing and commissioning procedures with checksheets.
11. Complete O&M manual (electronic and hardcopy).
12. Other procedures or quality documents specified herein or needed to clarify or document the work.

D. DEVICE LIST

The Equipment Supplier shall submit a list all electrical and mechanical devices.

PART 2 - PRODUCTS

2.01 Generator Characteristics

A. The generator shall be of the horizontal-shaft, hydraulic-turbine driven synchronous type complete with bearings, rotating brushless excitation system, and a closed system of ventilation with surface air-to-water coolers.

B. The generator shall be compatible with the turbine particularly in terms of vibration, speeds, loadings, and stresses.

C. The generator rating shall be as follows:

1.	Continuous maximum capacity at 0.9 pf, kVA	According to Supplier Design
2.	Power factor (lagging)	0.90
3.	Rated frequency, Hz	60
4.	Number of phases	3
5.	Rated voltage between phases, kV	6.9
6.	Rated speed, rpm	400
7.	Stator winding connection	Wye

D. All parts of the generator, including bearings, shall be designed to withstand all electrical, static, and dynamic stresses resulting from operation of the generator under rated operating conditions, including stresses caused by temporary conditions of overspeed and short circuits, as specified in these Contract Documents.

1. The stator assembly shall include the following:

   a. Setting and grouting sole plates and other embedded parts inside the housing.

   b. Assembly of the stator frame sections to form a solid, rounded structure.

   c. Complete assembly of stator laminations.

   d. Stator core magnetization test.

   e. Complete winding of the stator coils including installation of resistance temperature detectors.

2. The rotor assembly shall include the following:

   a. Assembly of the rotor ~~spider sections~~ and brake ring segments.

   b. Installation of field poles, including interpole connectors.

   c. Complete assembly of brushless excitation system to rotor shaft.

2.02 Temperature Rise

A. Winding Temperature Rise.

1. The rated maximum temperature rises when delivering maximum rated output continuously at rated voltage, rated speed, 0.90 power factor (lagging) and rated frequency, and with one cooler out of service, and with cooling air leaving the air coolers at not more than 40°C, shall not exceed the following:

   a. Stator Winding 85ºC

   b. Field Winding 80ºC

   c. Brushless Exciter Winding 80ºC

   d. Core and mechanical parts in contact with or adjacent to insulation 85ºC

2. The generator shall be capable of operating continuously at any voltage not more than 5% above or below rated voltage when delivering rated kVA at rated power factor (lagging) and rated frequency without exceeding the limiting temperatures specified above, and with cooling air leaving the air coolers at not more than 40°C.

3. The temperature of the generator shall be determined in accordance with the procedures specified in IEEE Standard 115, “IEEE Guide; Test Procedures for Synchronous Machines,” as described herein:

a. The temperature of the stator windings and core shall be determined by means of embedded resistance type temperature detectors (RTDs).

b. The temperature of the field windings shall be determined by the resistance method.

c. The temperature of the core fastenings, and other mechanical parts in contact with, or adjacent to; insulation shall be determined by the thermometer method.

B. Bearing Temperature Rise

1. The temperature of the thrust bearing shoes and the guide bearing shoes shall not exceed70°C, when operating under any load from 0 to 100% rated kVA, at rated voltage, rated frequency and unity power factor, conditions.

2. The temperature of the bearings shall be determined by resistance type temperature detectors located in the bearing shoes.

2.03 Electrical Characteristics

A. Generator shall be capable of continuous operation at rated kVA, at rated frequency and voltage, without exceeding rated temperature rise, at all power factors between rated and unity power factor.

B. Short-circuit ratio, not less than 1.1

C. Wave Distortion Factor

1. The telephone harmonic factor (THF) of the line-to-line terminal voltage when tested on an open circuit at rated speed and rated voltage not exceeding 3%.

2. Deviation factor of wave form, measured in percent of open-circuit line-to-line voltage, at rated voltage and frequency, not more than 10%.

D. Efficiency

1. The efficiency of the generator shall be guaranteed as determined from the losses and calculated from the corresponding generator efficiency at 25, 50, 75, 100% of rated output, at rated voltage and speed, and at rated power factor.

2. The generator losses shall include I^2R losses in armature and field windings, friction and windage losses, core losses, stray losses and excitation system losses (such as excitation power transformer, rectifier and voltage regulator losses) and portion of the thrust bearing loss produced by the thrust load due to the generator itself according to ANSI C50.12.

E. Special Requirements

1. The generator shall be capable of withstanding, without harmful deformation or damage, a 3-phase short circuit or any other short circuits for 30 seconds

at its terminals when operating at rated kVA and power factor, at 105% rated armature voltage and with fixed excitation.

2. The generator shall be capable of withstanding 150% of rated current for 30-seconds, without harmful deformation, mechanical damage or other damage, near rated voltage, without exceeding a temperature of more than 10ºC above rated temperature rise.

3. The field windings shall be designed to safely withstand two (2) times rated field current for not less than 30-seconds.

4. Under fault conditions, the generator shall be capable of withstanding, without damage, the per-unit negative-sequence-current (I_2), expressed in terms of rated stator current and the duration of the fault in seconds (t), limited to values which give an integrated product $(I_2)^2t$ at least equal to 40.

2.04 Mechanical Characteristics

A. Rotating Inertia:

1. Rotating inertia (WR^2) of the combined turbine-generator shall be such that the maximum momentary speed rise on full load rejection shall not exceed the design capabilities of the turbine-generator or 20% penstock pressure rise, whichever is less or limiting. The generator rotating parts shall have the maximum WR^2 that can be built into a standard size and frame for the machine selected speed without the use of a flywheel. The generator supplier shall coordinate all details and requirements regarding rotating inertia and speed rise with the turbine supplier.

2. Supplier shall indicate in the Bid Forms the turbine and generator WR^2 and corresponding Mechanical Starting Time (Tm) in seconds calculated as Tm = WR^2 x rpm^2 /1.6 x 106 x Hp (rated).

B. The generator shall be capable of withstanding the maximum runaway speed for 2 hrs without overheating of bearings or any harmful deformation or damage.

C. The generator noise level, as measured at points one meter vertically above the upper cover plate of the generator shall not exceed 85 dB(A).

D. The difference between the radial centers of the middle and two end planes of the stator bore shall be less than or equal to 10% of the measured value of the minimum air gap.

E. The average radial measurements of the middle and two end planes of the stator bore shall not vary by more than 10% of the measured value of the minimum air gap.

F. The first critical speed of the combined turbine and generator rotating parts, shall be at least 125% of the specified maximum runaway speed.

G. The generator shall meet the tolerances detailed in CEATI Report No. T122700-0381, section 5.0, Generator Tolerances.

2.05 Structural Details

A. The generator structural components shall be fabricated from ductile, structural-quality steel plate as per ASTM A516, or approved equal, to provide amble strength, rigidity and fatigue life.

B. The fabricated generator structural components shall be properly stressed relieved prior to machining to ensure dimensional stability. Components shall undergo thorough NDE at various stages of manufacture. Depending on the component NDE shall be performed on raw materials, before and after post weld heat treatment (PWHT) and after final machining.

C. The generator frame assembly shall generally consist of a stator frame, foundation anchoring and mounting assembly, core, and windings. The stator frame shall be fitted to the foundation plate assembly. The mounting assembly shall be anchored to the embedded anchor plate assembly. Bolts and dowels shall be provided for fastening the mounting assembly to the anchor plate assembly and for preserving the alignment between the frame mounting assembly and the foundation anchor plate assembly. An adequate number of dowels (minimum 2 per anchor plate) shall be provided in order to prevent any undue movement of the generator frame/mounting assembly on the anchor plates when the generator is subjected to stresses resulting from short circuit conditions.

   1. The generator mount shall support the weight of the entire generator assembly and shall have adequate rigidity and strength for safe operation under conditions of maximum unbalanced hydraulic thrust of the turbine runner or unbalanced conditions caused by short circuits, including short circuits of one-half of the field windings.

   2. Anchor plates and foundation bolts for the foundation anchoring and mounting assembly and supports shall be furnished.

D. The stator frame shall be made of rolled steel sheets designed to form a solid continuous frame. The stator frame shall be designed to keep the core in an isotropic cylindrical shape; to decrease the thermal stress under all generator operating conditions; and to provide adequate rigidity and strength against forces caused by short circuits, including short circuits of one-half of the field windings. Key bars and core studs shall be furnished with each frame for installing and securing the core. The stator frame shall be designed to provide for cooling air circulation through the core, rotor and air coolers.

E. The design of the foundation anchoring and mounting assembly, supports, frame, and structures in which resonance might become objectionable shall be so proportioned that any possibility of synchronism with the natural frequency, or any of its multiples, of the turbine or of the rotor and stator core vibration during unbalanced operations will be avoided.

F. Necessary platforms and supports, access hatches, stairways (or removable stairways), and hand-railings shall be provided for ready access to and for inspection of the bearings, brakes, and the speed signal generator.

G. Suitable guards, over or around all live and moving parts, shall be provided.

H. Provision shall be made for readily handling all parts during assembly or disassembly of a unit. Adequate provisions shall be made for attaching lifting devices, rails, slings, eyebolts, and other devices required for maintenance equipment.

I. Provisions shall be made for connecting the stator frame, upper and lower brackets, supports, oil and air coolers, and all other metal parts of the generator that require grounding in 2 locations to the station grounding system. All grounding connections, terminals and bolts shall be furnished.

2.06 Housing

A. A steel top cover of pleasing appearance, neatly constructed, and sufficiently rigid to prevent vibrations shall be furnished. The housing shall completely enclose the generator frame and stator air coolers. Removable panels shall be furnished to permit access to the generator top and bottom winding area, and the generator coolers. The top cover shall be divided into a number of sections, each having lifting provisions. The top cover shall be designed for a minimum live load of 100 lb/ft^2. All control valves, and switches inside the air housing shall be in a location permitting safe and convenient operation and inspection.

B. Access panels shall be furnished around the outside of the enclosure for accessing the generator coolers for maintenance and inspection. The panels shall be screw retained. The panels shall be labeled as generator cooler access with the cooler designation.

C. The top cover of the generator housing shall be provided with removable panels to provide access to the upper bearing, and the top of the stator. A ladder or stairway shall be provided to facilitate access.

2.07 Stator Core and Frame

A. The core of the generator shall be built up with high-grade, non-aging, .014 inch maximum thickness, Grade M19 laminated silicon steel with a maximum core loss of 1.55W/lb at 60Hz. The laminations shall be adequately locked to the stator frame with either a key bar or building bolt arrangement and securely held in place with clamping flanges at each end.

B. The stator core laminations shall comply with ASTM A677-98a standard for laminated steel. Each lamination shall be coated on both sides with an insulating, inorganic C5 varnish to minimize eddy current losses.

1. The inside air duct spacers shall be constructed from ~~non-magnetic stainless~~ magnetic steel. The spacers are to conform to an I-beam configuration, thus enhancing their mechanical stability.

2. Clamping flanges shall be magnetic steel, spot welded to the top and bottom stator iron laminations that have not been coated by C5 insulating varnish. The clamping fingers shall be held in place by stator heads constructed of 2-inch thick steel plate. The stator heads shall be pressed onto the core stack and secured in place by high strength studs and welded to structural tubing. The fingers shall be of sufficient length and rigidity to prevent looseness of laminations on the outer ends of the slots, and at the top and bottom of the

stator. The temperature of the fingers of the clamping flanges shall not exceed the temperature rise limit permitted for the core and mechanical parts in contact with or adjacent to insulation.

C. The stator frame shall be made of rolled steel sheets designed to form a solid continuous frame. The stator frame shall be designed to keep the core in an isotropic cylindrical shape; to decrease the thermal stress under all generator operating conditions; and to provide adequate rigidity and strength against forces caused by short circuits, including short circuits of one-half of the field windings. Leveling screws and openings for grouting shall be provided on the soleplates.

2.08 Stator Winding

A. The stator winding shall be provided with full Class F insulation or better. The insulation system shall be designed to provide high resistance to moisture and other contaminants.

B. All windings shall be copper and shall be assembled using form wound coils of the same size and shape.

C. Coils shall be wound with copper wire covered with strand insulation consisting of glass, Dacron, or other high temperature flexible insulating film.

D. The turn-to-turn insulation shall be adequate to ensure that all coils shall withstand switching or other surges well in excess of normal turn-to-turn voltage.

E. Coil insulation shall consist of mica tapes and shall be applied to the end turns, as well as the slot portion of the coil to ensure all parts of all coils are fully insulated to ground for the voltage class of the generator and for corona suppression.

F. After insertion of the coils in the stator slots, all end connections shall be brazed and insulated.

G. The end bracing system shall be capable of completely supporting each coil, as well as the entire assembly.

H. The uncured stator coils shall be installed into the core slots, secured in place and all coils connected to the appropriate number of phase connections. The entire stator assembly, core, windings, and frame housing, shall be given a global vacuum pressure impregnation (VPI) treatment. No spring-type filler wedging, or wedging locking system for removable type wedging will be provided because of the global VPI treatment.

I. End winding bracing material shall be Class F and shall include resin-impregnated conforming material, blocks, and glass twine.

J. The Supplier shall furnish bracing, as necessary, to prevent damaging movement of the winding. Top and bottom surge rings shall be furnished to accomplish the required bracing. Other bracing designs will be considered subject to review and approval by the Engineer.

2.09 Rotor

A. Poles.

1. The pole pieces shall be built up of high-grade, cold-finished, thin steel laminations (with oxidizing treatment) stacked under pressure and held together by means of end-plates and bolts, and fastened to the rotor rim by means of high strength studs and fasteners.

B. Field Winding

1. Field Winding: The field winding shall be insulated with Class “F” insulation as defined by ANSI C50.12 and shall consist of square copper wire. Insulation systems using asphaltic compounds will not be accepted. The turn insulation shall be thoroughly cemented to the adjacent turns. Heat treatment under pressure shall be performed to assure a compact assembly of the field winding.

2. Insulated supporting plates shall be provided at the top and bottom of each field coil, and shall be adequately supported at all points. Means shall be provided to compensate for shrinkage in the insulation and to maintain adequate pressure on the field coil.

3. Special care shall be taken to prevent the winding end from deforming or slipping due to the centrifugal force on the interpole links, and to prevent the field winding from slipping on the pole body.

4. The field windings and their insulation shall be capable of withstanding vibration, thermal displacement and stresses at maximum runaway speed, and capable of withstanding short-circuit and unbalanced current without mechanical and electrical failures.

5. The interpole links shall be designed to permit easy disconnection and removal of each pole and shall be sufficiently flexible to avoid failure due to vibrations and thermal displacement.

C. Damper Winding

1. The damper windings shall be of low resistance and rugged construction. They shall be designed for a calculated ratio of quadrature-axis subtransient reactance to direct-axis subtransient reactance not exceeding 1.30.

2. The damper windings including their connections shall be adequately supported to prevent mechanical failure due to vibration, thermal displacement and stresses at maximum runaway speed, and capable of withstanding short circuit and unbalanced current.

D. Brake Ring

1. A brake ring shall be provided on the driven side of the rotor rim or spider. The wearing surface of the brake ring shall be made of a heat-resisting and wear-resisting material for a high number of braking operations, and have adequate safety margin to allow braking under emergency conditions.

2. The brake ring shall be made up of segments, which are easily removable and renewable. Adequate provision shall be made for dissipation of the heat resulting from brake application and for thermal expansion of the brake ring segments without deformation.

E. Rotor Body.

1. The rotor body shall be a disk-type welded structure, or steel casting.

2. The rotor body shall be machined and shrunk fit to the generator shaft.

2.10 Turbine-Generator Shaft

A. The Turbine-Generator shaft shall be designed as one piece to be directly bolted to the Turbine Runner.

B. The shaft shall be made from forged, vacuum degassed, open hearth carbon or alloy steel properly heat treated and conforming to ASTM A668, Class E. Material certification of the shaft shall include chemistry, tensile strength, yield strength, elongation, hardness and supplemental Charpy impact testing. The shaft shall be 100% VT (surfaces) and 100% UT (volumetrically) examined. Coupling flange surfaces shall be 100% MT and 100% PT examined for relevant linear and rounded indications. All reportable ultrasonic indications must be recorded.

C. The shaft shall be of ample size and strength to ensure safe operation at any speed up to the maximum runaway speed without harmful vibration or distortion and also to operate at rated speed and maximum head with the wicket gates at maximum load position without exceeding maximum allowable stresses. The critical speed of the combined rotating parts of the turbine and generator shall be verified by both the turbine and generator manufacturers. The dynamic stability and critical speeds of the rotating system shall be analyzed. The first critical speed shall be at least 25% above the maximum runaway speed. The shaft shall be designed with an ample margin of safety against failure by fatigue. Design and manufacture shall be such as to avoid or reduce to a safe minimum all stress concentrations due to fillets, holes, keyways, or other discontinuities of the shaft section.

D. The shaft shall be completely finished in the shop and checked for runout in accordance with ANSI/IEEE 810. A runout inspection, as well as an entire shaft ultrasonic examination report shall be issued for review.

E. The shaft shall be accurately machined and finished to 125 micro-inch minimum throughout to obtain smooth finish and shall be polished at the bearing surfaces and at bands to 32 micro-inch or better suitable and accessible locations, below or above the guide bearings for shaft runout verification. The entire shaft shall be subjected to ultrasonic examination.

F. The shaft shall have a removable and replaceable stainless steel sleeve where the shaft passes through the shaft seal. A concentric, machined section between the shaft sleeve and the generator shaft coupling shall be turned and polished to 32 microinches for use during alignment.

G. The shaft sleeve shall be a separate component split axially and doweled to the shaft for anti-rotation. The split sleeve shall be machined for accurate fit up with the shaft from a centrifugally cast martensitic stainless steel in accordance with ASTM A743, Grade CA15 and heat treated to about 300 Brinell hardness. Sleeve shall be bolted together, and the splits shall be seal welded or sealed with an approved sealant. The sleeve outside diameter shall be accurately machined to ANSI/IEEE 810 tolerances. The machined finish of the shaft sleeve shall be compatible with the shaft seal materials.

H. The generator designer shall coordinate with the turbine designer to have the generator shaft bolt directly to the turbine runner. The Contractor shall design the shaft coupling for connection to the turbine runner to provide a precision fit. The shaft dimensions shall conform to ANSI/IEEE Standard 810-2015 “Standard for Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances” the shaft tolerances shall comply with table 6 items A, B, C, G, H, and 6 as well as table 7 items A, B, C, E, and F. The supply of bolts, nuts, nut or bolt guards, keys for the coupling to the turbine runner, if required, and all tools for fit-up to the runner and tightening the bolts shall be furnished by the generator supplier.

2.11 Shaft Seal

A. Refer to Section 15645 – Hydraulic Turbine for shaft seal requirements.

2.12 Thrust Bearing

A. The thrust bearing shall have ample capacity for the maximum unbalanced hydraulic thrust of the turbine. The thrust bearing shall have a removable one-piece runner and be arranged to permit easy inspection, adjustment, dismantling and assembly of the thrust bearing shoes without disturbing the rotor, stator or other components.

B. The safe, stable, and continuous operation of the bearing shall be guaranteed without harmful thermal distortion and mechanical deflection of the bearing lubricating face under all specified turbine and generator operating conditions. The design and structure of the bearing shall meet the following requirements:

1. The load and the temperature rise on the shoe shall be even and stable under all operating conditions. The loads on the shoes shall be automatically adjusted during operation.

2. The oil film between the runner and shoes shall be adequate under all normal operations.

3. The maintenance, dismantling and assembly of the bearing shall be convenient and easy.

4. Starting at normal operating temperatures, the thrust bearing shall be capable of operating without bearing oil cooling water for twenty (20) minutes, without wear that would reduce the design number of unit starts, at the maximum rated output followed by normal stopping.

5. Under emergency conditions, shall be capable of operating continuously without damage at any speed 50% to 110% of rated speed and shall be capable of operating without overheating, bearing wiping, or mechanical damage for 5-minutes.

C. Bearing shoes and segments shall be complete with provisions for insertion of RTD's specified elsewhere in this specification section. RTD provisions shall be placed in locations that will produce the hottest spot metal temperature readings.

2.13 Guide Bearings

A. Two guide bearings, shall be furnished which meet all normal and unbalanced operating requirements of the generator, including the unbalanced loads caused by a short circuit of one-half of the field windings. Either non-driven side or driven side guide bearing may be combined with the thrust bearing in the same enclosure. The guide bearings shall be of the segmental, screw-adjustable, oil immersed, babbitted type. The bearings shall be designed and constructed so that they can be easily dismantled, assembled and adjusted without disturbing the thrust bearing, the rotor or collector ring.

B. Bearings shall be complete with thermowells for insertion of RTD's specified elsewhere in this specification section. Thermowells shall be placed in locations that will produce the hottest spot metal temperature readings.

2.14 Bearing Insulation

A. The generator conducting parts such as stator, bracket, all supporting parts, seals and thermometer bulbs and detectors shall be adequately insulated against stray currents, which could be set up by the field of the generator and cause damage to the generator or turbine bearings. The insulation materials shall be designed to safely withstand all mechanical stresses incurred under operating conditions as specified in the specifications. The insulation shall be arranged to break the possible paths of such currents in not less than two (2) places in series so that positive tests for ground currents can readily be made.

2.15 Lubrication

A. The generator shall be provided with a complete, self-contained, lubricating system, which shall include the latest improvements to eliminate the throwing of oil and the escape of oil vapor from the bearings and lubricating system. Adequate provisions shall be provided, if necessary, to prevent excessive churning or aeration of the oil. The lubricating system for the upper bearing shall be separate from that of the lower one.

B. Each lubrication system shall include suitable oil reservoirs, oil piping, valves, filters, and necessary appurtenances. Two oil-level gages, one for each oil reservoir, shall be furnished.

C. Bearing oil lubrication shall be performed by oil circulation, which is achieved by shaft or runner rotation without an auxiliary pump.

D. An internal oil to water cooler of cupronickel 90/10 tube type shall be provided and shall have sufficient capacity to cool the oil with cooling water at the temperature specified. The coolers shall be designed to prevent accumulation of sediment. Provisions shall be made for effective removal of flux deposit and dirt. The cooler shall be designed for maximum water pressure of 125 psi. Separate water-supply and water-discharge lines to and from each heat exchanger shall be brought to an approved location.

2.16 Brakes

A. The generator shall be provided with brakes of sufficient capacity to bring the rotating parts of the generator and turbine, under normal operating conditions, to a stop from 25% rated speed within sixty (60) seconds after the brakes are applied, without injurious heating of the braking surface on the rotor, without field excitation on the generator, and with the leakage torque through the turbine wicket gate seals not exceeding an amount which will produce 2% of the full rated turbine torque. Materials used shall be such that galling will not occur during braking.

B. The brake shoes shall be provided with suitable, friction wearing surfaces (free of metal and asbestos), which shall be readily renewable. The brake shoes and wearing surfaces shall be keyed or otherwise securely fastened to the jack pistons.

C. Control equipment for automatic and manual actuation of the brake system shall be furnished. The brake piping supplying pressurized fluid to the brake cylinders shall be of sufficient size and free of restrictions to permit complete release of the brake shoes, after completion of the braking cycle. Each brake cylinder shall be provided with a position switch with two (2) electrically independent, single pole double-throw contact circuits. The position switches shall change position when the brake shoe reaches the reset or release position. Each brake shoe shall be spring reset to disengage the shoe from the brake ring when the pressure is relieved.

2.17 Cooling

A. The generator shall be furnished with surface air coolers spaced symmetrically around the periphery of the stator frame for a closed, recirculating, cooling system. Water headers shall be furnished with the coolers. Each connection between coolers and the headers shall be of the flanged type. A valve shall be provided in each connection between each cooler and the header so that any cooler on the generator can be readily disconnected and removed for maintenance or repair without interfering with the operation of the remaining coolers. The outlet valve for each cooler shall be globe type for use in balancing flows. The inlet valve shall be a gate type. A gauge cock with 1/4-inch threaded connection shall be furnished at the inlet and outlet of each cooler. The discharge header shall have a vented standpipe to ensure that the coolers will always be full of water. An indicating flow monitor shall be furnished on the water discharge line from each cooler.

B. The coolers shall be of cupronickel 90/10 tube type, with finned tubes expanded into corrosion resistant tube sheets. The water boxes shall be non-ferrous and constructed with removable cover plates to permit access to all tubes and shall be arranged to permit removal of any cover for inspection and cleaning of the tubes without disturbing the water pipe connections. A valve and hose connection shall be provided to permit complete draining of each cooler. Each cooler shall be designed for a maximum water pressure of 125 psi and shall be hydrostatically tested at the factory. Automatic air vents shall be provided at the top of each cooler and at other locations in the system, as required. Lifting lugs shall be furnished for each cooler.

C. The surface air coolers shall have sufficient cooling capacity to maintain the temperature of the air leaving the coolers at 40ºC, or less, with the generator delivering continuously rated output, and with 25ºC cooling water temperature, and with 25% of the tubes blocked. Flow velocity in the tubes shall not exceed 5 fps. Velocities in the piping shall not exceed 7 fps.

D. The circulation of air shall be by means of the generator rotor fans. The air shall circulate through the stator core, frame and coolers and back into the top and/or bottom of the rotor.

E. One RTD shall be furnished and installed in the discharge air from each cooler.

2.18 Heaters

A. The Equipment Supplier shall furnish an adequate number of thermostatically controlled electric heaters within the generator housing to prevent condensation of moisture or sweating when the generator is idle. Heaters shall be in 2- or 3-KW units and shall be wired in delta for operation on a 480-V, 60-Hz circuit. The wiring shall be extended to Generator Terminal Box.

2.19 Generator Terminal Box

A. Wiring required for connection to devices outside the generator air housing, including wiring from spare contact circuits, shall be routed to a generator terminal box located on the outside of the air housing.

B. Intermediate terminal boxes shall be arranged inside the generator air housing, as required by the Contractor, and shall be mounted in accessible locations with ample working space.

2.20 Excitation System:

A. The brushless excitation system shall consist of:

1. A coupled exciter armature with rotating rectifier assembly. The armature winding shall be provided with full Class F insulation or better.

2. The rotating exciter shall use a three phase full wave rectifier assembly with hermetically sealed silicon diodes protected against abnormal transient conditions by a multi-plate selenium surge protector. The diodes shall be designed for safety factors of 5 times voltage and 3 times current.

3. The rotating brushless exciter shall be mounted outboard of the top generator guide bearing.

4. Stationary exciter field. The exciter winding shall be provided with full Class F insulation or better.

5. All additional components necessary to supply and control generator field excitation, including equipment for regulation of the generator terminal voltage.

B. The excitation and voltage regulation system shall be designed for manual and automatic control from the main control switchboard and remote workstation.

C. The exciter panel shall contain the exciter and voltage regulation for the unit as described on the Main Control Switchboard Layout Drawing.

D. Excitation Controller: A digital excitation controller shall be provided to control the excitation output of the brushless exciter. The excitation control system shall be Basler DECS-200, or equal.

1. Regulation Accuracy

   The voltage regulator shall provide ± 0.25% voltage regulation from no load to full load at rated power factor and constant generator frequency. Steady state stability shall equal ± 0.1% at a constant load and generator frequency. The temperature drift shall equal ± 0.5% for 0 to 50°C temperature change. The Underfrequency (volts/hertz) characteristic slope from 0 to 3.0 P.U. shall be adjustable in 0.1 P.U. increments. The field current regulation (FCR) shall equal ± 0.1% of the nominal value for 10% of the bridge input voltage change or 20% of the field resistance change. Shall provide ± 2.0% of the nominal VA rating at the rated frequency. Shall provide ± 0.02 PF in the set point PF for the real power between 10 and 100% at the rated frequency.

2. Field Overvoltage Protection

   Shall be adjustable in increments of 1.0 VDC from 1.0 to 325 VDC rated output voltage with a 0.2 to a 0.2 to 30 second inverse time delay settable in increments of 0.1 seconds.

3. Field Overcurrent Protection

   Shall be adjustable in increments of 0.1Adc steps of rated field current from 0 to 16Adc excitation current setting with an inverse time delay.

4. Exciter Diode Monitor (EDM)

   The voltage regulator control shall be able to detect open and shorted diodes on the brushless generator. This shall be done by requiring user input of the number of generator poles and the number of exciter poles (both shall be adjustable from 0 to 20 in increments of 2). The open and shorted diode ripple threshold shall be adjustable from 0 to 100% of field current. The open diode protection time delay shall be adjustable from 10 to 60 seconds, and the shorted diode protection time delay is adjustable from 5 to 30 seconds.

5. Generator Undervoltage Protection

   Shall be adjustable in increments of 1Vac from 0 to 30kV sensing voltage setting with a 0.5 to 60 second time delay settable in increments of 0.1 seconds.

6. Generator Overvoltage Protection

   Shall be adjustable in increments of 1Vac from 0 to 30kV sensing voltage setting with a 0.1 to 60 second time delay settable in increments of 0.1 seconds.

7. Generator Loss of Field Protection

   Shall be adjustable in increments of 1kVar from 0 to 3,000 MVar, with a 0.1 to 9.9 second delay settable in increments of 0.1 seconds.

8. Loss of Sensing

   The loss of sensing setting for both balanced and unbalanced generator voltage shall be adjustable from 0 to 100% of nominal generator voltage. The protection delay shall be adjustable from 0 to 30 seconds in 0.1 second increments.

9. Soft Start

   Voltage regulator shall have a user adjustable setting to govern the rate at which the generator voltage is allowed to build up. Setting shall be functional in AVR and FCR with an adjustable rate of 1 to 7200 seconds in one second increments.

10. Over/ Underexcitation Limiting

    The limiter response time shall be less than three cycles for overexcitation limiting (OEL) and shall be adjustable based on generator ratings for underexcitation limiting (UEL).

2.21 NAMEPLATE

A. A nameplate shall be provided as defined in ANSI C50.12. The nameplate shall be brass or stainless steel, no smaller in size and thickness to the original generator nameplate, and shall be cast, stamped, or engraved with the following information:
   1. Manufacturer's name.
   2. KVA rating.
   3. Power factor.
   4. Stator voltage.
   5. Field voltage at rated kVA.
   6. Field current at rated kVA.
   7. Frequency.
   8. Rotation speed.
   9. Rated stator temperature rise.
   10. Field temperature rise by resistance.
   11. Date of manufacture.

2.22 ACCESSORIES

A. Bearing Temperature: One RTD shall be installed in the metal of every other thrust bearing shoe and at least two RTDs shall be installed in the metal of each of the guide bearings with leads brought out to a NEMA 13 terminal box. The RTD's shall be dual element spring loaded type with armor braid extension cable. The RTD elements shall be 3-wire platinum, 100 ohms at 0ºC plus or minus 1ºC and having a temperature coefficient of resistance (alpha) of 0.00385 ohms/ohm/ºC.

B. Bearing Oil Temperature: One RTD shall be installed in the oil reservoir for the thrust and upper guide bearing and one RTD in the reservoir for the lower guide bearing with leads brought out to a NEMA 13 terminal box. The RTD's shall be located in the area of anticipated maximum temperature. The RTD's shall be dual element spring loaded type mounted in an immersion well with terminal head. The RTD elements shall be 3-wire platinum, 100 ohms at 0ºC plus or minus 1ºC and having a temperature coefficient of resistance (alpha) of 0.00385 ohms/ohm/ºC.

C. Bearing Oil Level: Oil level switches shall be installed in the thrust bearing and lower guide bearing oil reservoirs. Level switches shall be provided for high level alarm, low level alarm, and low level shutdown. The level switches shall be furnished with two electrically independent sets of contacts, one each for high and low level alarms. The contact leads shall be brought out to a NEMA 13 terminal box. Contacts shall be rated for 125 volt dc operation. The level switches shall be GEMS ALS-800 Type 5, or equal.

D. Flow Monitor: Water flow monitors shall be furnished for the stator air coolers and the thrust bearing oil coolers. The vane style flow monitors shall be located in the cooling water return lines. The flow monitor body shall be brass with stainless steel internal moving parts and Buna N seals. The flow monitor shall be furnished with a local flow indicating meter and adjustable flow switches. Two flow switches shall be furnished with electrically independent sets of contacts one each for low flow alarm and low flow shutdown. Contacts shall be rated for 125 volt dc operation. The flow monitors shall be Universal Flow Monitors, Inc. Series SN/MN, or equal.

2.23 TERMINAL BOXES, CONDUIT, AND WIRING

A. The Equipment Supplier shall furnish and install all terminal boxes, internal wiring, and internal conduits for auxiliary circuits for the generator. The internal wiring for continuation external to the generator shall be brought to the main terminal box and provisions shall be made for connections to external conduits and wiring.

B. The terminal boxes shall not affect the air-tightness of the generator air housing and terminal boxes shall be NEMA 13 type construction.

2.24 SPARE PARTS

Required Spare Parts for the Generator:

A. Ten control power fuses of each type used.

B. One set of each type power fuse used.

C. One set of rectifier diodes used for the rotating brushless exciter.

D. Any other spare part recommended by the manufacturer

PART 3 - EXECUTION

3.01 GENERATOR SHOP ASSEMBLY

A. Each generator shall be completely assembled, tested and inspected in Supplier’s shop prior to delivery to the Project site. Adjoining components shall be fitted, doweled and bolted together to ensure proper fit and alignment during field erection and assembly. Assembled components shall be shop-welded in their final positions, as much as shipping limitations and field installation conditions will permit.

B. Shop assembled components shall be inspected for accurate fit, correctness of dimensions and clearances, accuracy of alignment and ease of movement. Errors, misalignments and other quality deficiencies shall be corrected.

C. Controlling dimensions and small clearances of the assemblies shall be measured and recorded on illustrated shop inspection forms, showing both the design drawing dimensions and the actual measured dimension.

D. The Owner will periodically witness and/or inspect the Work in progress at the Supplier’s shop. Supplier’s costs associated with periodic witness and inspections shall be at no additional cost to the Owner.

E. Supplier shall maintain a checklist to make sure all work tasks are completed and to record when they were completed. As the Work progresses, the list shall be modified to include any items missed on the original list or remove any items not required. The checklist shall include any testing or adjustments that will be required before the unit is started or released for operation. Checklist shall provide for sign-off by the Owner at critical points of progress, including, but not limited to, milestones, hold points, major witness inspections, and testing.

3.02 GLOBAL VPI MANUFACTURING TEST REQUIREMENTS (STATOR WINDING)

A. General

1. The Supplier shall provide all equipment and labor to perform the tests summarized below. Deviation from the outlined methods and test values shall only be made with prior approval from the Owner.

2. Formal signed and dated reports of all test results, equipment used and conclusions shall be submitted to the Owner during the fabrication and included in the final report.

B. DC High Potential Test

1. At completion of manufacturing of the stator the Supplier shall perform a DC high potential test at a minimum of 39 kV DC held for one minute on each phase separately with the other phase and the RTDs grounded.

2. A failure during the DC high potential test may result in a rejection of the stator.

C. Insulation Resistance and Polarization Index Test

1. At completion of manufacturing of the stator, Insulation Resistance and Polarization Index Test shall be made on each phase as described in the latest revision of IEEE 43. The phases not under test and the stator RTDs shall be solidly grounded. The test voltage shall be 5,000VDC. Winding insulation resistance shall not be less than 100 megaohms. Polarization index shall not be less than 2.0.

D. Winding AC High Potential Test

1. At completion of manufacturing of the stator each phase of the winding shall be given a high potential test. The phase not being tested and all RTDs shall be solidly grounded.

2. The test shall be performed in accordance with the latest revision of ANSI C50.12 and IEEE 115. The Supplier shall provide the high potential test set. The test value shall be a minimum of 15kV, 60 Hz, for a period of one minute.

3. A failure during the AC high potential test may result in a rejection of the stator.

E. RTD Test

1. At completion of manufacturing of the stator, each detector shall be tested for operation continuity and insulation resistance momentarily at 500 V between the three leads together and ground. This test shall be repeated after the slot is wedged.

2. RTDs that fail the test are to be rejected and documented in the final report.

F. Winding Resistance Check

1. At completion of manufacturing of the stator, the armature resistance of each winding shall be measured at an Owner-specified hold point in accordance with the requirements of the latest revision of IEEE 115. If the resistance variance between the highest and lowest phase readings exceeds 0.5% or deviates from the calculated value by more than 0.5%, the Supplier shall investigate and submit an explanation with expected consequences in writing to the Owner.

3.03 RFACTORY ACCEPTANCE TESTING (FAT)

A. Thirty days (30) prior to the factory acceptance test, the Supplier shall provide detailed factory assembly and test procedures for review and approval.

B. Supplier shall perform mechanical, electrical, functional and performance tests to demonstrate that the equipment and accessories are fully functional and meet specified or guaranteed performance requirements.

C. Supplier shall perform hydrostatic and leakage tests on all fluid pressurized systems and pressure containing parts. A combined list of such pressure tests shall be prepared by the Supplier. The list shall include design pressures, test pressures, and test dates, and when completed it will serve as an inspection record that is to be submitted to the Owner.

D. Hydrostatic tests shall be 150% of design pressure and applied for 60 minutes. Under the hydrostatic pressure test none of the parts shall show evidence of distress and welded joints shall be leak tight. After the hydrostatic pressure test has been satisfactorily completed, reduce the internal pressure to the design pressure to perform a leakage test for 60 minutes. Under the leakage test all seals, packing and mechanical joints for leakage. Leakage shall be zero.

E. Supplier shall carryout the following factory testing and quality checks:

1. Generator Efficiency Test: The generator efficiency tests shall be made on the generator at the factory in accordance with the NEMA and IEEE standards and with the Test Procedures for Synchronous Machines, IEEE No. 115.

2. Winding Resistance to five significant digits and Insulation Resistance: Measure winding resistance and insulation resistance and record with temperature of the following windings:
   a. Generator stator winding.
   b. Generator field winding.
   c. Stator temperature detectors.

3. Insulation Resistance and Polarization Index: An Insulation Resistance and Polarization Index Test shall be performed on the rotor. The test duration shall be 10 minutes with a test voltage of 500 VDC.

4. Copper-to-Copper Resistance Test: The rotor shall have its resistance measured and recorded from the collector rings to five significant digits and the reference temperature measured as documented in the final report.

5. Surge Voltage Test: Every rotor pole shall be given a surge voltage test in accordance with the latest revision of IEEE 522. The test voltage impulse shall have a 200 ns or less time to an amplitude of 2.0 kV or 120 volts per turn, whichever is higher. Pass/fail criteria are per IEE 522. Coils that fail the surge voltage test are to be rejected, stripped, re-insulated, and re-tested to the same test requirements. All details of the initial test, re-work, and re-testing shall be documented in the final report. This test shall be applied at least once in the factory while the coil is pressed to a force equivalent to the centrifugal force on the winding at a speed of 150 RPM.

6. Air Gap Measurement: Provide air gap measurement between the generator stator and rotor. The airgap measurements shall meet the requirements of CEATI Report No. T122700-0381, Hydroelectric Turbine-Generator Units Guide for Erection Tolerances and Shaft System Alignment, Dated June 2015

7. Phase Rotation: Check and record generator rotation and phase sequence, and record results on the machine nameplate.

8. Open Circuit Saturation Curve: With generator operating at rated speed, run an open circuit saturation curve at the following voltage points: 25%, 50%, 75%, 100%, 110%, 120%, 130%, 140% and up by 10% increments until reaching rated field voltage. Record the following values for each point:
   a. Generator output voltage.
   b. Field voltage.
   c. Field current.
   d. Drive fixture kilowatts.

At the end of curve run, record generator field resistance.

9. Residual Voltage: With generator operating at rated speed, with no field applied, record the following values:
   a. Generator output voltage.
   b. Generator field voltage.

10. Short Circuit Saturation Curve: With generator operating at rated speed, run a short circuit saturation curve at the following current points. Start at 125% and decrease to 100%, 80%, 50% and 25%. Record the following values for each point:
    a. Generator output current.
    b. Field voltage.
    c. Field current.
    d. Drive fixture kilowatts.

At the end of curve run, record generator armature and field resistance.

11. Friction and Windage: Record drive fixture kilowatts when driving generator at rated speed without excitation.

12. Harmonic Analysis: With generator operating no load at rated speed and voltage, take and record harmonic values on both the line to line and line to neutral voltage.

13. Wave Form Picture: With generator operating no load at rated speed and voltage, take the wave form picture of both the line to line and the line to neutral voltage wave form.

14. T.I.F. Reading: With generator operating at no load, open circuit, at rated speed and voltage, take and record the balanced residual T.I.F. values with no more than 120 volts on meter.

15. Space Heaters: Apply voltage to the space heaters and record the following values:

    a. Phase.

    b. Voltage.

    c. Current.

    d. Kilowatts.

16. Mechanical Run and Balance: Measure and record vibrations before, during and after overspeed test. Measure and record bearing temperatures. Each rotor shall be dynamically balanced to Grade G1 per ISO 1940.

17. Mechanical Overspeed Test: Measure and record overspeed and adjust overspeed switches.

18. Sound Level: Measure and record sound level at a distance of one (1) meter from generator surface.

19. High Potential Test:

    a. Generator Stator Winding: Apply a 60Hz AC voltage of 1,000 volts plus twice the rated voltage for 60 seconds.

    b. Generator Field Winding: Apply a 60Hz AC voltage of 10 times the rated excitation voltage but not less than 3000 volts for 60 seconds.

20. Final Insulation Resistance: Measure and record the insulation resistance, temperature of winding and relative humidity, as the final test prior to shipment, of the following windings:

    a. Generator stator winding.

    b. Generator field winding.

21. Field Pole Polarity: Check field pole polarity to see that all field coils are installed and connected properly.

    a. Every pole shall be given a surge voltage test in accordance with the latest revision of IEEE 522. The test voltage impulse shall have a 200 ns or less rise-time to an amplitude of 2.0 kV or 120 volts per turn, whichever is higher. Pass/fail criteria are per IEEE 522.

22. Air Cooler Flow: Measure air velocity through the coolers.

23. Bearing Insulation:

    a. Prior to final assembly of the completed machine, the bearing bracket and bearing assembly shall be checked to determine the bearing insulation integrity.

    b. Record bearing insulation resistance.

24. Verification that the generator meets the requirements of CEATI Report No. T122700-0381, Part I and Part III

F. The Supplier shall notify the Owner of the testing schedule with proper advance notification to allow optional witnessing by the Owner upon completion. Failed tests shall be reported with the mitigation action taken.

G. Provide detailed factory assembly and test procedures.

H. Submit a detailed quality docket for all shop and factory testing.

I. All test results, inspections, and supporting calculation shall be documented in final report.

3.04 INSTALLATION

A. Installation will be performed by a general contractor under a separate contract with the Owner. Supplier shall provide the services of a trained field service representative to advise and assist during installation of the generator.

B. Prior to shipment, the Supplier shall provide detailed installation drawings and procedures that will be implemented by the general contractor. The procedures shall include illustrated site inspection forms showing both design and actual measured dimensions, tolerances and acceptance criteria. Installation tolerances shall conform to CEATI Report No. T122700-0381, Hydroelectric Turbine-Generator Units Guide for Erection Tolerances and Shaft System Alignment, Parts I and III.

C. The generator supplier's representative shall certify correct installation, in compliance with installation requirements before proceeding with field testing and commissioning.

3.05 FIELD TESTING AND COMMISSIONING

A. The Supplier shall be responsible for all field testing and commissioning activities related to all equipment under the Supplier's scope of supply, including all labor, materials, instruments and test equipment, instrument calibration, and the cost of test engineer(s). Data collection shall be electronic.

B. The general contractor and the Owner's plant staff will assist with the field testing and commissioning under the direction of the Supplier's field representative(s). The participation of the Owner and/or the general contractor in testing and commissioning activities shall not relieve the Supplier of its responsibility for the proper execution of the tests.

C. The Supplier and general contractor shall cooperate with Owner to establish mutually satisfactory dates for testing and commissioning activities.

D. The Supplier shall prepare and submit detailed test procedures to the Owner for review and approval. Each unit shall be tested by the Supplier in accordance with the procedures established in Owner-approved test procedures.

E. The Supplier shall perform testing and commissioning to demonstrate compliance with specified requirements, performance guarantees and expected operational characteristics. The turbine operational tests shall be performed in conjunction with the generator operational tests. Basic operation data shall be recorded. These shall include pressures, temperatures, flows, etc. The scope of testing and commissioning shall include the turbine-generator and all auxiliaries.

F. The measurement of power output shall be at the generator main and neutral terminals using instrument transformers of accuracy class 0.2 during acceptance testing. The calibrated three-wattmeter method shall be used.

G. The following generator tests will be performed by the general contractor prior to unit rotation:

1. Insulation resistance measurements and polarization index.
2. High potential (dielectric) tests
3. Calibration and functional tests of instrumentation.
4. Calibration and functional tests of protection systems.
5. Functional tests on bearing oil system.
6. Functional tests on bearing oil cooling water system
7. Functional test on stator cooling water system.
8. Functional tests on braking system.

H. The following tests will be performed on each unit after non-rotational testing has been completed:

1. Initial no-load, mechanical run.
2. Initial load run.
3. Excitation system tests
4. Governor system tests
5. Overspeed tests.
6. Synchronization test
7. Load rejection tests
8. Index tests.
9. Capacity tests
10. Functionality test

I. Runaway Speed Test (Optional): Within the warranty period, the Owner may elect to have a runaway speed test performed on the unit to confirm that the guarantee with respect to runaway speed has been fulfilled. If such test is undertaken, it will be performed at the highest head available at the time of the tests, with no load on the generator and with the wicket gates fully open and the blades in their proper relationship (on-cam) and also in the false relationship (off-cam) giving the highest runaway speed. The test will be of not more than one minute duration from the time the maximum speed has been attained.

J. Verification that the generator meets the requirements of CEATI Report No. T122700-0381, Part I and Part III

K. Test Report: A complete report (or reports) of the site tests performed on the equipment, including initial operation and performance tests shall be furnished within 30 days of commissioning unit. The report shall include a description of the items tested and of the instrumentation; a list of test personnel; calibrations of measuring equipment; test procedures; tabulations of measurements taken; sample calculations; test results, including final adjustments, settings, and turbine performance curves; and a discussion of the test results and conclusions.

3.06 FIELD SERVICES

A. The Supplier shall provide the services of a field service representative to advise the Owner and general contractor performing the installation work. The Supplier shall also be responsible for all field testing and commissioning as specified elsewhere.

B. The Supplier’s field representative shall provide training and instruct the Owner's plant staff in matters regarding the operation and maintenance of the equipment. Plant operating staff will participate in performing all operating functions during start-up and initial operation under the Supplier's field representative supervision.

C. The Supplier shall provide the cost for field service representative(s) as shown in the Bid Schedule.

D. The field service representative(s) shall be qualified to perform the following tasks:

1. Installation oversight

2. Field checkout and trial operation.

3. Initial no-load, mechanical run.

4. Initial load run.

5. Load rejection tests.

6. Index tests.

7. Capacity tests.

8. Functional tests.

9. Training of Owner’s staff.

END OF SECTION

SECTION 16220
GENERATOR TERMINATION CABINET

PART 1 - GENERAL

1.01 GENERAL

A. The Equipment Supplier shall provide detail design, manufacturer, testing and delivery of the generator termination cabinet.

1.02 CODES AND REFERENCE STANDARDS

A. Perform the Work of this Section in accordance with the following standards as modified and supplemented herein:

1. ANSI American National Standards Institute
2. IEEE Institute of Electrical and Electronic Engineers
3. NEC National Electric Code
4. NEMA National Electrical Manufacturer's Association

B. Design and manufacture shall meet applicable California State and federal codes, rules and regulations.

1.03 SUBMITTALS

A. Submittals required by this section of the Technical Specification shall be submitted for Engineer review in accordance with Section 01300 – Submittals. Submit the following information:

1. Data
    a. Bill of Materials
    b. Manufacturer's data sheet for all major components.
    c. Nameplate schedule.
2. Drawings
    a. Cabinet outline drawings showing overall dimensions.
    b. Arrangement drawings showing locations of all major components.
    c. Equipment installation drawings including anchoring details.
3. Electrical load list detailing all power requirements for the termination cabinet, if any.
4. Instructions
    a. Factory test procedures.
    b. Installation instructions.
    c. Operation and Maintenance Manuals, specific to the project.
5. Reports
    a. Factory Test Report.

B. The general arrangement drawings depicting all equipment and devices, AC schematic, three-line diagram, terminal wiring diagram, bill of materials and calculations shall be submitted.

PART 2 - PRODUCTS

2.01 GENERAL

An enclosure of ample size to enclose the generator phase and neutral lead terminations, potential transformers, current transformers, station class surge capacitors, station class surge arresters, neutral resistor and transformer, and excitation controller power supply transformer and fusing. The enclosure shall be a free standing, front access cabinet with lockable hinged doors. Bus phasing shall be identified (A, B, C) top to bottom and left to right from cabinet front. All Work and connections shall be insulated at 8kV. As an option the Contractor may include these components in two separate enclosures, one for the generator line and neutral termination equipment and the other for the neutral grounding equipment.

A. The three generator main potential leads (T1, T2, T3) and the three neutral stator leads (T4, T5, T6) shall be brought out of the generator to the generator termination cabinet. The leads shall be adequately supported and braced to protect against movement during short circuit conditions. Insulated termination points shall be furnished for connection to the generator main cable bus. The neutral point connection shall be furnished with provisions for connection to the generator grounding transformer. Room shall be provided on the neutral leads for installation of the required current transformers.

2.02 ENCLOSURE

A. The cabinet shall be constructed of formed sections of smooth, rolled sheet steel, 10 gauge, welded together and reinforced, where necessary, with structural steel members. The surface of all panels shall be free of pits, noticeable scratches, dents, or other defects.

B. Access panels shall be provided on the front and both sides for ease of termination and future maintenance. All access panels shall be gasketed and screw retained. Handles shall be furnished on access panels for ease of handling.

C. A 2-inch by ¼-inch copper ground bus shall be provided for grounding the transformer. All ground termination points shall be silver-plated. A #2/0 ground lug shall be furnished for grounding to the station ground system.

D. The entire enclosure shall be finished ANSI #61 gray over a phosphate type rust inhibitor.

2.03 SURGE EQUIPMENT

A. The station class surge protection capacitors shall be connected in the generator termination cabinet. The surge capacitors shall be rated 0.5 μF, 9.0 kV maximum operating voltage.

B. A set of station class surge arresters shall be connected in the generator termination cabinet. Station class, metal oxide varistor (MOV) surge arresters shall be provided. The surge arresters shall have a voltage rating of 10 kV with a maximum continuous voltage (MCOV) of 8.4 kV.

2.04 CURRENT TRANSFORMERS

A. Current transformers shall be installed on the generator neutral leads and generator phase leads as indicated on the Drawings. The transformers shall be single ratio, ring type with an insulation class of 8.7 kV, and 75 kV BIL. The current transformers shall have a minimum ANSI relay accuracy of C100 or T100 and a minimum ANSI metering accuracy rating of 0.3 at B0.5.

B. Current transformers shall conform to IEEE C57.13 and have 800:5 ratio.

2.05 NEUTRAL GROUNDING EQUIPMENT

A. The neutral grounding equipment shall be sized such that the power dissipated in the resistor is equal to no less than 100 percent and no more than 110 percent of the kVA or to the closest standard rating that would be developed in a phase-to-ground short circuit in the generator circuit if the generator were ungrounded. The generator winding capacitance, the surge protective capacitance, and the capacitance of the generator leads should be considered in this calculation. The ground fault current shall be limited to less than 10 amperes. The calculations shall be submitted for review and approval of the Owners or Owner’s Engineer.

B. The grounding resistor shall be stainless steel punched grid type. The resistor elements shall be mounted in frames, which allow for expansion of the resistor elements. The resistor shall have a maximum temperature rise of 375ºC with a 1-minute time rating. The resistor elements shall be GE Type IC9141, or equal.

C. The grounding transformer shall be dry-type with the windings completely encapsulated in an epoxy type resin.

1.	Number of phases	1
2.	Frequency	60 Hz
3.	Continuous rating	As Required kVA
4.	Cooling method	Self Cooled
5.	Temperature rise	150°C
6.	Primary rated voltage	7000 Volts
7.	Secondary rated voltage	240/120 Volt
8.	Primary BIL	60 kV
9.	Secondary BIL	10 kV

D. The copper windings shall be completely encapsulated in an epoxy-resin applied to the winding under high vacuum.

E. The core shall be constructed of grain-oriented silicon steel and shall provide a sound mechanical structure for support of the coils. All exposed steel surfaces of both clamps and core steel laminations shall be coated with a permanent moisture resistant material to prevent rusting. The entire core-and-coil assembly shall be supported on resilient type mounting pads.

A single pole disconnect switch shall be included upstream to the grounding transformer.

F. A stainless-steel diagrammatic nameplate shall be attached to the transformer.

2.06 TERMINAL BLOCKS

A. Terminal blocks for secondary low voltage wiring shall be molded type, with barriers, rated not less than 300 volts, 25 amperes, suitable for conductors ranging between No. 18 and No. 10. White marking strips shall be provided with function codes (abbreviations indication function of the terminal point). Each connected terminal of each block shall have a function code placed on the marking strip with permanent marking fluid.

B. Terminal blocks used for current transformer secondary lead terminations shall be provided with removable short circuiting type links for short circuiting all phase connections to ground.

C. The low voltage terminal blocks shall be installed in a separate enclosure isolated from the medium voltage equipment. Access to the terminal blocks shall be available without entering the medium voltage equipment area.

2.07 NAMEPLATE

A. Nameplate shall be furnished on the front surface of the cabinet. The nameplates shall read “GENERATOR TERMINATIONS” and shall be legible from reasonable angles of observation and from distances of at least 10 feet.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The cabinet shall be completely assembled at the manufacturer’s facility and all accessories installed and adjusted. The cabinet shall be subjected to all the manufacturer’s standard production tests and testing in accordance with the requirements of IEEE C37.23 including dielectric tests. No equipment shall be shipped until it has been tested and the certified test report has been reviewed by the Owner and the Engineer.

END OF SECTION

SECTION 16230
GENERATOR SWITCHGEAR

PART 1 - GENERAL

1.01 SCOPE

A. This section outlines the design, manufacture, and testing requirements for 7.2 kV, 1,200A, metal-clad, generator switchgear for the Pine Flat Hydroelectric Unit #4.

Owner prefers that the switchgear be manufactured by ABB-Hitachi and include ABB-Hitachi generator circuit breaker and major medium voltage power components. Equipment Supplier shall have an option to submit optional pricing for other manufacturers in the following preferred order- Siemens, Eaton.

B. The following codes and standards shall apply:

IEEE C37.20.2	Standard for Metal-Clad and Station-Type Cubicle Switchgear
ANSI C37.06	Standard for Switchgear – AC High-Voltage Circuit Breakers Rated on a Symmetrical Basis – Preferred Ratings and Related Required Capabilities
IEEE C37.09	Standard Tests Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C57.13	Standard Requirement for Instrument Transformers

1.02 SUBMITTALS

A. Submittals required by this section of the Technical Specification shall be submitted for Engineer review in accordance with Section 01300 – Submittal. Submit the following information:

1. Data
   a. Bill of Materials.
   b. Manufacturer’s data sheet for all major components.
   c. Nameplate schedule.
2. Drawings
   a. Electrical schematic and interconnection shop drawings.
   b. Switchgear outline drawings showing overall dimensions.
   c. Arrangement drawings showing locations of all major components.
   d. Equipment installation drawings including anchoring details.

3. Electrical load list detailing all power requirements for the generator switchgear.
4. Instructions
   a. Factory test procedures.
   b. Installation instructions.
   c. Operation and Maintenance Manuals, specific to the project.
5. Reports
   a. Factory Test Report.

PART 2 - PRODUCTS

2.01 GENERAL

A. The switchgear shall be of the 7.2 kV, metal-clad, indoor, 3-phase, 60 Hz, dead-front, freestanding type construction. The switchgear cubicle shall include a vacuum circuit breaker, bussing, and other devices as indicated. Construction shall conform to IEEE C37.20.2 and ANSI C37.06.

B. The switchgear and all attached assemblies shall be rated to withstand UBC seismic Zone 3 criteria.

2.02 ENCLOSURE

A. The switchgear enclosure shall be designed for indoor service. The sections shall be furnished with split front doors and full height rear doors. The front doors shall be furnished with lockable latches. The rear doors shall be screw retained. All side panels shall be removable for easy access to bus bar connections.

B. All steel surfaces shall be thoroughly cleaned and phosphatized. The final finish shall be ANSI 61 light gray.

2.03 GENERATOR CIRCUIT BREAKER

A. The generator circuit breaker shall be horizontal draw-out type, capable of being withdrawn on rails. The breaker shall be operated by a motor-charged stored energy spring mechanism. Provisions shall be furnished for charging the stored energy system manually. The circuit breaker primary contacts shall be silver-plated.

B. The breaker cell shall provide indication when the circuit breaker is in the engaged, test, and disconnected position. A latching mechanism shall be provided to prevent inadvertent removal once the breaker has been racked into the engaged position.

C. The circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. A contact wear gap indicator shall be provided for each vacuum interrupter. The breaker front panel shall be removable for ease of inspection and maintenance.

D. The circuit breaker secondary contacts shall be silver-plated and shall automatically engage in the breaker operating position, and shall be able to be manually engaged when in the test position.

E. Interlocks shall be furnished to provide the following:

1. Prevent closing of the breaker between the operating and test positions.
2. Trip the breaker upon insertion or removal from the housing.
3. Discharge the stored energy mechanism upon insertion or removal from the housing.

F. The circuit breaker shall be electrically operated by the following voltages:

1.	Close	125 volts dc
2.	Trip coil 1	125 volts dc
3.	Trip coil 2	125 volts dc
4.	Spring charge motor	125 volts dc

G. The circuit breaker shall be furnished with four form “a” auxiliary contacts and four form “b” auxiliary contacts for external use. These contacts shall be in addition to contacts required for normal breaker operation. The auxiliary contacts shall be NEMA P300 rated for use with 125 volts DC.

H. A means shall be provided for manual operation of the circuit breaker when in the connected, test, or disconnected positions.

I. The circuit breaker shall have the following ratings and characteristics:

1.	Nominal voltage rating	7.0 kV
2.	Maximum voltage rating	8.25 kV
3.	BIL rating	95 kV
4.	Continuous current	1200 Amp
5.	Nominal 3-phase MVA Class	500 MVA
6.	Maximum short circuit current	40,000 Amp rms symmetrical @ 8.25KV
7.	Maximum closing & latching	66,000 Amp asymmetrical
8.	Rated interrupting time	3 cycles

J. Owner prefers Generator Circuit breaker shall be manufactured by ABB-Hitachi. Supplier shall submit optional pricing for other options in the following preferred order –

1. Siemens

2. Eaton

2.04 GROUNDING SWITCH

A. A manually operated grounding and test device shall be provided. The ground and test device shall be designed to insert into the circuit breaker cell and provide access to the primary disconnect devices of the circuit breaker cell. The device shall provide means for grounding the primary circuits or for conducting high potential test procedures.

B. The ground and test device shall have the following ratings and characteristics:

1.	Nominal voltage rating	7.0 kV
2.	BIL rating	95 kV
3.	Continuous current	1200 Amp
4.	Nominal 3-phase MVA Class	500 MVA
5.	Maximum short circuit current	40,000 Amp rms symmetrical @ 8.25KV

C. The device shall be provided with six stabs at the rear for accessing the top and bottom primary phase circuits. An upper and lower access door shall be provided on the front of the device for accessing the upper and lower test ports. Each door shall be provided with provisions for padlocking in the closed position.

D. A ground shoe shall be provided which engages the breaker cell ground bus to the device.

E. Three flexible grounding cables shall be provided. One end of each cable shall be bolted to the device ground bar. The other end shall be provided with provisions for bolting to one of the primary contact bars in either the upper or lower test port.

F. A racking mechanism shall be provided to engage and disengage the device in the breaker cell. The mechanism shall be operated by the same hand crank used to operate the circuit breaker racking mechanism.

G. The ground and test device shall be provided with a rollout latch to prevent inadvertent removal from the cell once fully engaged.

2.05 BREAKER CUBICLE

A. The stationary primary contacts shall be silver-plated and recessed within porcelain supports. An automatic shutter shall cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the housing.

B. The stationary secondary contacts shall be silver-plated multiple sockets.

C. A ground contact shall be furnished to ground the breaker between and including the connected and test positions.

2.06 BUS

A. The switchgear shall be furnished with a copper, 3-phase, 3-conductor main bus with a continuous current carrying capacity of at least 1,200 amp with a hot-spot temperature not greater than 65°C above ambient. The momentary current rating of all buses and connections shall be not less than 33,000 amp rms symmetrical at 8.25 kV.

B. The main bus shall have epoxy, flame retardant, and track resistant insulation. Glass polyester or porcelain main bus supports shall cover the bus opening between housings to provide a non-combustible fire wall. All bus joints shall be silver-plated, bolted, and insulated with boots.

2.07 GROUND BUS

A. A bare ¼ inch by 2-inch copper ground bus shall extend the full length of the switchgear. The ground bus shall be individually secured to each section and to the breaker ground contacts.

B. All joints and contact surfaces shall be silver-plated.

2.08 CIRCUIT BREAKER TERMINATIONS

A. The line and load terminals of the breaker cubicle shall be bussed to the generator cable bus duct terminations.

B. Transition terminations between the generator cable bus duct and the switchgear bus shall be coordinated between the switchgear and cable bus duct manufacturers.

2.09 CURRENT TRANSFORMERS

A. Metering current transformers shall be furnished for the generator and California ISO metering. The transformers shall be single ratio, ring type with an insulation class of 8.7 kV, and 60 kV BIL. The transformers shall have a minimum IEEE relay accuracy rating of C100 and a minimum ANSI metering accuracy rating of 0.3 at B0.5.

B. Current transformers shall conform to IEEE C57.13 and have 800:5 ratio.

C. A dedicated current transformer compartment shall be furnished for ISO metering.

2.10 POTENTIAL TRANSFORMERS

A. Three separate potential transformer (PT) compartments shall be furnished for generator metering, protection and synchronizing, and for California ISO metering. One compartment shall be furnished for generator side metering and synchronizer sensing (two PT's), one compartment for line side synchronizing sensing (one PT), and one compartment for line side California ISO metering (two PT's).

B. The PT's shall be trunion mounted. Each transformer primary and secondary shall be furnished with current limiting fuses. With the PT's in the withdrawn position, the PT's shall be completely disconnected, visibly grounded, and isolated from the high voltage. The PT's shall conform to IEEE C57.13 and have the following characteristics

1. Rating 7000 – 120 volts
2. Ratio 60:1
3. Class 15 kV
4. BIL 95 kV
5. IEEE accuracy Class 0.3W,X,M,Y,Z

2.11 EXCITER POWER SUPPLY

A. A supply transformer with primary current limiting fuses and secondary dual element fuses shall be provided to furnish excitation power to the excitation controller.

B. The transformer shall be three phase, 60 Hz, self-cooled, ventilated dry type. The transformer shall be designed specifically for supplying a thyristor-controlled rectifier load and shall be of sufficient rating to deliver the required input power to the excitation controller. The transformer shall be designed for a maximum winding temperature rise of 185ºC.

C. Primary and secondary fusing shall be provided for the transformer. Primary fusing shall be current limiting type with 8 kV minimum voltage rating. Primary fusing shall be trunion mounted. With the primary fusing in the withdrawn position, the fuses shall be completely disconnected, visibly grounded, and isolated from the high voltage. Secondary fusing shall be dual element type with voltage and current rating coordinated with the excitation equipment requirements.

D. Low voltage terminals shall be isolated from the high voltage compartment. Access to the low voltage terminals shall not require exposure to the high voltage connections.

2.12 DC CONTROL CIRCUIT

A. Two separate dc circuits shall be furnished for the circuit breaker control. The spring charge and breaker close circuit shall be fused with pull-out type isolating fuse block. The trip circuit shall have a pull-out type isolating fuse block with "slugs" placed in the fuse holders. The breaker controls shall be capable of operating within the following dc control voltage ranges.

1. Closing and continuous operation 90 – 135V dc
2. Tripping 70 – 140V dc

B. A dc under voltage relay shall be connected to the generator circuit breaker control circuit to indicate when the dc control power is turned off or excessively low.

2.13 CONTROL WIRING

A. The control switchboard assembly shall be completely wired, and wires for connections to remote equipment shall be brought to terminal blocks. All wiring shall be neat and workmanlike, without splices and with a uniform arrangement of circuits. Wire bundles or single wires shall run in straight lines with 90º corners, where change of direction is required.

B. Switchboard wiring, inside the panel, shall be #16 AWG or larger. Wiring shall be UL type, SIS, or MTW, flexible stranded copper, control wire. Minimum conductor sizes shall be as follows:

1. Current transformer circuits: #12 AWG minimum

2. Potential transformer and control circuits: #14 AWG minimum

3. Alarm circuits: #16 AWG minimum

4. Instrument and communication circuits: #18 AWG minimum

5. Where possible wiring shall be run in plastic wire duct with covers. Where it is not possible to contain the wiring in the duct, the wiring shall be wrapped with plastic spiral binding. The plastic wire duct and spiral binding shall be as manufactured by the Panduit Company, Hoffman or approved equal.

6. Wire bundles crossing hinges shall be securely clamped to both the door and the panel, and run parallel to the hinge for at least half the door length to prevent chafing. No splicing shall be permitted in the wire duct or spiral wrapped wire bundles.

7. The wires connecting the various devices to each other and terminal blocks shall be labeled at both ends with destination codes. Wire labels shall be white heat shrink polyolefin sleeves with black lettering. Wire labels shall be Floy Tag & Manufacturing, Inc. Type FT-200S, or approved equal.

8. Terminal blocks for control wiring shall be molded type, with barriers, rated not less than 300 volts, 25 amperes, suitable for conductors ranging between No. 22 and No. 14. White marking strips shall be provided with function

codes (abbreviations indication function of the terminal point). Each connected terminal of each block shall have a function code placed on the marking strip with permanent marking fluid.

9. Terminal blocks used for current transformer secondary lead terminations shall be provided with removable short circuiting type links for short circuiting all phase connections to ground.

2.14 CONTROL SWITCHES

A. All control switches shall be of the rotary switchboard type with handles on the front and the operating mechanisms on the rear of the panel. Contacts of all switches shall be self-aligning and shall operate with wiping action. A positive means of maintaining high pressure on closed contacts shall be provided. The rear switch covers, or plates shall be readily removable for inspection of contacts. Switches shall be Electro Switch Type 24, or equal.

B. The control switches shall include but not be limited to:

   1. One 3-position, spring-return-to-center circuit breaker maintenance control switch engraved “Trip - Close” shall be furnished for the circuit breaker. The control switch shall be interlocked with the circuit breaker cell position switches to only permit circuit breaker operation via this switch when the circuit breaker is in the “Test” or fully withdrawn position. Operation of the circuit breaker by this switch shall be prevented whenever the circuit breaker is in the fully engaged position.

2.15 INDICATING LIGHTS

A. Indicating lamp assemblies shall be LED assemblies, push-to-test of the switchboard type, suitable for 125 vdc service, with appropriate color caps and integrally mounted resistors. The LED lamps shall be replaceable from the front of the panel. All color caps shall be interchangeable, and all LED lamps shall be of the same type and rating. The lamp assemblies shall be GE Type ET-16-LED or approved equal.

B. Two indicating lamps shall be furnished. One green lamp to indicate the circuit breaker is open and one red indicating lamp to indicate the circuit breaker is closed.

2.16 SPARE PARTS

A. As a minimum the following spare parts shall be included:

   1. Three of each type and size of power fuse used.
   2. Ten of each type and size of control power fuse used.
   3. Five of each type indicating lamp used.
   4. One circuit breaker trip coil.
   5. One circuit breaker close coil.
   6. One quart of finish paint to be provided for field touch up.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The switchgear shall be completely assembled at the manufacturer's facility and all accessories installed and adjusted. The switchgear shall be subjected to all the manufacturer's standard production tests and testing in accordance with the requirements of IEEE C37.20.2 and IEEE C37.09, including dielectric tests. The manufacturer shall also verify that all wiring is correctly installed and that all devices are properly functioning. No equipment shall be shipped until it has been tested and the certified test report has been reviewed by the Engineer.

B. A copy of heat run type test report on identical switchgear assembly (with breaker, bus and auxiliary components included) shall be provided to the engineer and owner.

END OF SECTION

SECTION 16250
CALIFORNIA ISO METERING CABINET

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section covers the requirements for Pine Flat Hydroelectric Unit #4, California ISO Metering Cabinet.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. American National Standards Institute (ANSI)

ANSI C12.10	American National Standard for Physical Aspects of Watthour Meters
ANSI C12.20	American National Standard for Electricity Meters
ANSI C37.90	Relays and Relay Systems Associated with Electric Power Apparatus
ANSI C39.1	Requirements for Electrical Analog Indicating Instruments
ANSI C62.41	IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

B. National Fire Protection Association (NFPA)

NFPA-70	National Electric Code (NEC)

1.03 SUBMITTALS

A. Submittals required by this section of the Technical Specification shall be submitted for Engineer review in accordance with Section 01300. Submit the following information:

1. Data
   a. Bill of Materials.
   b. Manufacturer's data sheet for all major components.
   c. Nameplate schedule.
2. Drawings
   a. Electrical schematic and interconnection shop drawings.
   b. Cabinet outline drawings showing overall dimensions.
   c. Arrangement drawings showing locations of all major components.
   d. Equipment installation drawings including anchoring details.

3. Electrical load list detailing all power requirements for the iso metering cabinet if any.
4. Instructions
    a. Factory test procedures.
    b. Installation instructions.
    c. Operation and Maintenance Manuals.
5. Reports
    a. Factory Test Report.

PART 2 - PRODUCTS

2.01 CABINET CONSTRUCTION

A. The ISO Metering cabinet shall be of the wall-mounted, indoor NEMA-12 type construction.

B. A full height front door with latch shall be provided. The door shall be furnished with padlocking provisions.

C. A continuous copper grounding bus bar not less than 1/4 inch by 1 inch shall be furnished.

D. A fluorescent lighting fixture(s), with on-off switch, shall be provided inside the ISO metering cabinet and shall be suitably located to provide adequate interior lighting.

E. The finish shall consist of a coat of air-dried enamel applied to clean and phosphatized steel for internal and external parts. Prior to shipment, the completed assemblies shall be given an exterior finish coat of gray enamel ANSI No. 61, and an interior white finish.

F. Nameplates

1. Furnish nameplates for instruments, indicating lights, and other items where the circuit and function of the device cannot be otherwise readily determined.
2. Nameplates shall be made of white plastic cut through to a black background. The lettering shall be of a size and design such that it will be legible from reasonable angles of observation and from distances of at least 10 feet.

2.02 CONTROL WIRING

A. The ISO metering assembly shall be completely wired, and wires for connections to remote equipment shall be brought to terminal blocks. All wiring shall be neat and workmanlike, without splices and with a uniform arrangement of circuits. Wire bundles or single wires shall run in straight lines with 90º corners, where change of direction is required.

B. Wiring inside the panel shall be #18 AWG or larger. Wiring shall be UL type, SIS, or MTW, flexible stranded copper, control wire. Minimum conductor sizes shall be as follows:

   1. Current transformer circuits: #12 AWG minimum
   2. Potential transformer and control circuits: #14 AWG minimum
   3. Instrument and communication circuits: #18 AWG minimum

C. Where possible wiring shall be run in plastic wire duct with covers. Where it is not possible to contain the wiring in the duct, the wiring shall be wrapped with plastic spiral binding. The plastic wire duct and spiral binding shall be as manufactured by the Panduit Company, Hoffman or approved equal.

D. Wire bundles crossing hinges shall be securely clamped to both the door and the panel, and run parallel to the hinge for at least half the door length to prevent chafing. No splicing shall be permitted in the wire duct or spiral wrapped wire bundles.

E. The wires connecting the various devices to each other, and terminal blocks shall be labeled at both ends with destination codes. Wire labels shall be white heat shrink polyolefin sleeves with black lettering. Wire labels shall be Floy Tag & Manufacturing, Inc. Type FT-200S, or approved equal.

F. Terminal blocks for control wiring shall be molded type, with barriers, rated not less than 300 volts, 25 amperes, suitable for conductors ranging between No. 22 and No. 14. White marking strips shall be provided with function codes (abbreviations indication function of the terminal point). Each connected terminal of each block shall have a function code placed on the marking strip with permanent marking fluid.

G. Terminal blocks used for current transformer secondary lead terminations shall be provided with removable short circuiting type links for short circuiting all phase connections to ground.

2.03 Test Switches

A. The ISO meter shall be furnished with potential and current test switches. The test switches shall contain individual switches for isolating the input, output, potential and current circuits prior to inserting the test plug. The current switches shall automatically short-circuit the current transformers when opened. Each test switch shall be furnished with a test plug to permit testing the meter assembly from separate sources of potential and current. The test switches shall be ABB Flexitest Type FT-1, or approved equal.

2.04 ISO METER

A. General

   1. Meter shall be Scientific Columbus JEMSTAR, Landis+Gyr MAXsys 2510, Nexus 1262, 1272 Series or approved equal.
   2. The following consumption quantities shall be recorded:
      a. Kilowatt-hours generated.

b. Kilovar-hours generated.

c. Kilovoltamp-hours generated.

3. The following demand quantities shall be recorded:

a. Kilowatt-hours generated.

b. Kilovar-hours generated.

c. Kilovoltamp-hours generated.

4. The Meter shall be programmable to ignore the reverse quantities for reverse consumption and demand quantities.

B. ISO Metering Functions

1. When power is applied to the Meter, it shall immediately begin recording total kilowatt-hours. This function shall be performed regardless of whether the Meter is programmed or not and shall not require a battery.

2. Demand ISO Metering Functions

a. As a minimum, the Meter shall be programmable for fixed and/or rolling interval demand calculations on kilowatts and kilovars.

b. A battery shall not be required to perform demand calculations, to save the results, or to communicate the results to a handheld meter reader connected to the optical port.

c. Demand intervals shall be programmable for duration of 1, 5, 10, 15, 30, or 60 minutes.

d. The demand interval shall be composed of an integral number of subintervals. Subinterval duration shall be programmable duration of 1, 5, 10, 15 or 30 minutes.

e. Demand functions shall be capable of temporary suspension for a programmable time interval after power is restored following a power outage. The length of time shall be programmable from zero to 60 minutes in one-minute intervals.

f. After a demand reset, further manual demand resets shall be prevented with a programmable lockout time. A demand reset from a Meter Programmer connected to the optical port is not subject to this delay and can be initiated as frequently as required.

3. Load Profile Function

a. ISO requires that the Meter provide load profile recording of interval data for 1 to 4 channels of consumption quantities.

b. Date and time shall be stored with the load profile interval data.

c. Load profile data shall use a “wraparound” memory that stores new interval data by writing over the oldest interval data.

d. The load profile function shall be capable of storing and communicating a minimum of 30 days of 4 channel, 5-minute data, in addition to allowances for event recording (power outages, resets, time sets, etc.)

e. The load profile function shall have the capacity to count and store at least 16,000 counts in a 15-minute period..

f. Load profile data recording shall continue while the Meter is communicating with a Meter Programmer connected to the optical port.

4. Function During Power Disturbances

   a. During power line disturbances such as brownout or outage conditions, and during transportation to the installation site, the Meter shall maintain all meter data as well as time keeping functions. Display and communication functions are not required during these conditions.

   b. The Meter shall withstand all of the following outages during a continuous five year or longer service without the need to maintain its auxiliary power system, including replacing the battery:

      (1) 20 short outages per year at less than 30 seconds per outage.

      (2) 40 days of continuous/cumulative outage.

   c. During a power outage critical program and billing data shall be written to nonvolatile memory. When power is restored, data shall be returned to active memory and data collection resumed.

   d. Following a power outage, register “catch-up” time shall be a maximum of 30 seconds. During the “catch-up” time the Meter shall still calculate consumption and demand quantities. Optional outputs shall also function during this time.

   e. During power outages, time shall be maintained with a cumulative error of no more than 2 minutes per week (0.02%)

   f. The Meter shall record the date and time of any power outage. This data shall be available through remote interrogation of the meter.

5. ISO Meter Test Mode Function

   a. The Meter shall have the capability of a Test Mode that suspends normal metering operation during testing so that additional consumption and demand from the tests are not added to the Meter’s totals.

   b. The Test Mode function shall be activated by a Meter Programmer connected to the optical port or RS-232 port.

   c. Activation of the Test Mode shall cause all present critical billing data to be stored in nonvolatile memory and restored at the time of exit from the Test Mode.

   d. Upon activation of the Test Mode, register displays shall accumulate beginning from zero.

C. LCD Display

1. The Meter shall have a liquid crystal display (LCD) for displaying the consumption and demand quantities.

2. Digits for displaying the consumption and demand quantities shall be 0.3-inch minimum height, and be legible in normal daylight conditions from a distance of six feet by an observer. The viewing angle shall be minimum of ± 15 degrees from the front of the Meter face line of sight.

3. The display shall provide the following:

   a. Six digits for display of the consumption and demand quantities with decimal points for the three least significant digits.

   b. Three digits for numeric display identifiers (ID numbers).

   c. Alternate and Test Mode Displays.

   d. Continuous potential indication for each phase.

   e. End of interval indicator.

f. Visual representation of the magnitude of the power flow.

g. Visual representation of the magnitude of the reactive power flow.

h. Annunciators for use with the consumption and demand quantities.

4. Consumption and demand quantities shall be programmable to display leading zeros in four, five, or six digits with a decimal point at any of the least significant three digits.

5. Time shall be displayed in 24-hour military format.

6. Date shall be displayed programmable in either Day/Month/Year or Month/Day/Year format.

7. The displays shall have at least three operating modes:

   a. Normal Mode – In this mode the display shall scroll automatically through the programmed displays for normal meter reading.

   b. Alternate Mode – In this mode the display shall scroll automatically, scroll manually, or freeze for up to one minute for alternate programmed displays.

   c. Test Mode – In this mode the display shall scroll automatically, scroll manually, or freeze for up to one minute for test quantity displays.

8. Display ID numbers and display sequence shall be independently programmable for each of the three modes.

9. Display times shall be programmable.

10. The Meter shall have programmable identifiers for the Meter ID, and the current program ID. The Meter ID shall be capable of eight alphanumeric characters.

D. Meter Diagnostics

1. The Meter register shall be capable of performing a self-test of the register software. As a minimum, the self-test shall be performed at the following times:

   a. Whenever communication is established to the register.

   b. After a power-up.

   c. Once per day.

2. As a minimum, the following diagnostic checks shall be performed during a self-test:

   a. Check the back-up battery capacity.

   b. Verify the program integrity.

   c. Verify the memory integrity.

3. The meter shall be capable of detecting and logging that the maximum number of pulses has been exceeded during a demand interval.

4. Any detected error or warning shall be stored in memory and an error or warning code displayed on the display.

5. Error code displays shall freeze the display.

6. Warning code displays shall be programmable to one of the following choices:

   a. Freeze the warning code on the display.

   b. Ignore the warning code (not displayed).

   c. Warning code display at the end of the Normal, Alternate, or Test Modes display sequence.

7. Error or warning conditions shall only be reset upon an explicit command invoked via the Meter Programmer or upon some other explicit action by the Meter Technician.

E. Accuracy

1. The Meter shall meet or exceed the accuracy specifications contained in ANSI C12.20-1997 over its entire service life without the need for adjustment.
2. The Meter shall be factory calibrated by the Supplier to provide the following level of accuracy:
   a. ± 0.2% at full load at power factor of 100%.
   b. ± 0.25% at full load at power factor of 50% lag.
   c. ± 0.25% at full load power factor at 50% lead.
   d. ± 0.25% at light load at power factor of 100%.
3. Meter accuracy and calibration tests, both shop and field, shall require only standard test equipment. No special Laboratory-type equipment or test procedures shall be required to assure accuracy of the Meter.
4. Pulse outputs shall have the same accuracy as the Meter displays.

F. Clock

1. The clock internal to the Meter shall be accurate within 2 minutes per week (0.02%) when not synchronized to the line frequency and shall be resettable through the ISO communications interface. ISO will transmit a periodic master synchronizing signal to the meter.
2. The internal clock shall have two modes of operation as follows:
   a. The clock shall synchronize with the line frequency until an outage occurs. During the outage, the clock will then synchronize with its own internal crystal. When power returns, the clock shall resynchronize with the ISO's master synchronizing signal and follow line frequency.
   b. The clock shall always synchronize with its own internal crystal, as a default in the absence of line frequency.
3. The choice of clock mode shall be programmable.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The metering cabinet shall be completely assembled at the manufacturer's facility and all accessories installed and adjusted. The cabinet shall be subjected to all of the manufacturer's standard production tests. The manufacturer shall also verify that all wiring is correctly installed and that all devices are properly functioning. No equipment shall be shipped until it has been tested and the certified test report has been reviewed by the Engineer.

END OF SECTION

SECTION 16300
TURBINE AND GENERATOR CONTROL SWITCHBOARD

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section covers the requirements for automating the Pine Flat Hydroelectric Unit #4 turbine, generator, and water management systems. A programmable logic controller (PLC) based control and monitoring system shall be designed, detailed, and furnished.

B. Pine Flat Hydroelectric Plant

1. The Equipment Supplier shall design, and furnish a PLC based automation system for controlling and monitoring Unit #4 at the Pine Flat Hydroelectric Plant. The Master Station shall be in the control switchboard along with a local Human Machine Interface (HMI), preferably a minimum of 19-inch monitor with touchscreen capabilities. A suitable “Remote” PC workstation shall be provided at the existing Pine Flat control room that mimics all the control and monitoring capabilities built into the Master Station in the control switchboard. The control and monitoring of the unit from this remote station shall be the default operation while the “Local” station in the control switchboard shall be considered as the second terminal for the unit control and monitoring. A dedicated Remote/Local selector switch shall be provided at the “local” control switchboard for this purpose. Connection between the Local and Remote station shall be via Fiber cable with compatible network switches. Necessary computer accessories- keyboard, mouse and a printer station shall be supplied.
2. The graphic screens and tag allocation for the Local HMI and Remote Workstation shall be submitted for Owner and Engineer approval. The main default screen shall mimic the unit single line diagram and connection to the Transmission line including all the switchyard equipment (not under the scope of this specification). The graphics shall be clear, legible to read and status change indicators shall reflect the status of the equipment. Generation data, voltage, frequency and other basic generating unit parameters shall be displayed both at the unit and at the line level.
3. A Master PLC system shall be installed and located in the Unit 4 Turbine and Generator Control Switchboard. The Master PLC shall perform the following functions:
   a. Control and monitoring of the turbine-generator unit including the unit governor, exciter voltage regulator, and Turbine Shutoff Valve (TSV). The local terminal box for each of these equipment shall have its own Remote I/O modules and communicate with the Master Station PLC. A network drawing with I/P addresses for each of the components shall be submitted for Owner and Engineer review.
   b. Monitor various plant auxiliary systems including, but not limited to, battery system, sump levels, intrusion, and fire detection.
   c. An operator interface terminal (OIT) shall be furnished at the Unit 4 Turbine and Generator Control Switchboard for implementing control and monitoring functions via the PLCs.

4. The Unit 4 Turbine and Generator Control Switchboard (refer to Section 16310) shall be furnished for controlling and monitoring the Unit. The switchboard shall contain all the necessary equipment for automatically control and monitor the Unit turbine and generator systems. The Master PLC shall be located within the switchboard. The switchboard shall be furnished with all the necessary controls for transferring to manual plant operation in the event the Master PLC fails or is down for maintenance. Manual plant operation shall utilize switchboard controls for manual control of the Unit. Generator protective relay systems shall also be furnished.

C. Software and Training

1. All software including operating licenses, manuals, documentation, and electronic files used for developing and implementing the automation system PLCs shall be furnished and become the property of the Owner.
2. Automation system training shall include a course in the theory, detailed operation, testing, and maintenance and troubleshooting of the automation system. Submit instructor background and qualifications, course outline, course material and subject matter for the theory and operation, testing, and maintenance and troubleshooting of the automation system.
3. Training course material shall include the use of site-specific Operations and Maintenance Manuals, to the maximum extent possible.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. Institute of Electrical and Electronics Engineers (IEEE)

IEEE C37.2	Standard Electrical Power System Device Function Numbers

B. National Fire Protection Association (NFPA)

NFPA 97	Electrical Standard for Industrial Machinery

1.03 SUBMITTALS

A. Submittals for this section shall be submitted in accordance with Section 01300 – Submittals.

B. The following manufacturer’s data sheets shall be submitted by the Equipment Supplier for review by the Owner and Engineer:

1. Manufacturer’s data sheets for all PLC components used in the system including but not limited to: CPUs, power supplies, I/O modules, communication modules, OIT, and software.
2. Manufacturer’s data sheets for all of the turbine-generator control switchboard components including but not limited to: control switches, pushbuttons, indicating meters, indicating lights, auxiliary control relays, power supplies, and system protective relays.

C. The following control and monitoring system descriptive information and drawings shall be submitted for Owner and Engineer review:

1. Turbine and generator control system block diagrams and descriptive text detailing operation of the new system controllers. All modes of operation shall be covered including, but not limited to, start, stop, synchronizing, loading, unloading, gate operation, automatic and manual operation, emergency stop, and alarms.

D. PLC program details shall be submitted for Owner and Engineer review. The programming shall be fully annotated with sufficient information for determining operation of the system. A full algorithm for the overall control system architecture shall be submitted for Owner and Engineer review. A PDF copy of the complete PLC programming shall also be submitted.

E. Operation and Maintenance (O&M) instructions for the control systems. Instructions shall include accessing and changing control setpoints, all user-adjustable parameters, and monitoring and control functions within the PLC. O&M requirements for all turbine-generator control switchboard devices shall also be included.

F. Factory and site test procedures for the control systems (refer to Section 16360 – Control and Monitoring Systems Testing). The Supplier shall submit acceptance test procedures and requirements for the control systems. These requirements shall be reviewed by the Owner and Engineer and the final approved procedures and requirements shall be used for commissioning the units. As far as practically possible, an integrated control system test shall be planned for the Factory Acceptance Test (FAT). Components and signals not available shall be simulated using suitable analog or discrete signals in lieu of the actual signals.

G. After completion of the factory and site testing the Equipment Supplier shall submit test reports documenting the test procedures and test results. Refer to Section 16360 – Control and Monitoring Systems Testing for test report details.

PART 2 - PRODUCTS

2.01 REFER TO THE FOLLOWING SECTIONS FOR PRODUCT REQUIREMENTS:

A. Section 15970 – Turbine Governor

B. Section 16310 – Turbine and Generator Control Switchboard

C. Section 16360 – Control and Monitoring Systems Testing

PART 3 - EXECUTION

3.01 PROGRAMMING

A. The PLC programming shall be performed by a programmer experienced in programming hydroelectric and water control systems. The programmer shall have a minimum of 5 years experience in programming systems like those specified herein.

B. All program documentation shall be reviewed and approved by the Owner and Engineer prior to implementation. Refer to submittal requirements specified herein.

C. All programming software shall be compatible with the latest addition of Microsoft's operating system. The PLC programming shall be in the form of functional blocks and developed as less complex as possible. The programming software, instruction manuals, and data files shall become the property of the Owner at the completion of the project.

3.02 TESTING

A. Refer to Section 16360 – Control and Monitoring Systems Testing for shop and site testing requirements.

END OF SECTION

SECTION 16310
TURBINE AND GENERATOR CONTROL SWITCHBOARD

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section covers the requirements for Pine Flat Hydroelectric Unit #4 turbine and generator control system. A programmable logic controller (PLC) based control and monitoring switchboard and remote PC Workstation shall be designed and furnished.

1.02 REFERENCES, SPECIFICATIONS, CODES AND STANDARDS

A. American National Standards Institute (ANSI)

ANSI C39.1	Requirements for Electrical Analog Indicating Instruments

B. Institute of Electrical and Electronics Engineers (IEEE)

IEEE C37.90-1989	IEEE Standard for Relays and Relay Systems Associated with Electrical Power Apparatus
IEEE C37.90.1-1989	IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

C. National Electrical Code (NEC)

NEC-2017	National Electric Code

1.03 SUBMITTALS

A. Refer to Section 16300, “Turbine Generator Control Requirements” for submittal requirements.

1.04 TURBINE AND GENERATOR CONTROL SWITCHBOARD FUNCTIONS

A. The switchboard controls shall be integrated with the generator switchgear, exciter-regulator, Turbine Shutoff Valve (TSV), generator auxiliaries, and governor. The switchboard shall be designed to provide full automatic operation with manual backup capabilities.

B. Control Switchboard Start and Stop Description:

1. The control switchboard shall be able to automatically start, stop, load, and unload the turbine-generator unit. Initiation of turbine-generator control shall be via the switchboard operator interface terminal (OIT). The switchboard shall also be furnished with manually actuated controls for manual control of the turbine-generator should the PLC fail or be disabled for maintenance.

2. The starting sequence shall automatically proceed through a sequence of pre-start condition checking, starting auxiliary systems, and then starting the unit. The start sequencing shall include, but not be limited to, the following steps:
   a. Open TSV.
   b. Check and confirm that all auxiliary systems are in automatic mode.
   c. Confirm TSV open.
   d. Start auxiliary systems and check for proper flows, pressures and levels.
   e. Wicket gate lock off.
   f. Generator thrust bearing high pressure lift pump on.
   g. Generator brakes off.
   h. Open wicket gates to speed no load position.
   i. Start exciter.
   j. Automatically synchronize and close generator circuit breaker.
   k. Automatically adjust wicket gates to maintain preset flow set point.
3. The Equipment Supplier shall fully automate startup and verification of proper operation of the turbine-generator start auxiliary systems.
4. The normal stopping sequence shall automatically proceed through a sequence of unloading and stopping the turbine-generator. After the unit has come to a full stopped condition all systems shall be reset and made ready for an automatic or manual system start. The stop sequencing shall include, but not be limited to, the following steps:
   a. Unload turbine to speed no load condition and trip the generator breaker and excitation off.
   b. Generator thrust bearing high pressure lift pump on.
   c. Generator brakes on at ~30% speed.
   d. Unit at full stop.
   e. Governor off.
   f. Wicket gate lock on and shutdown unit auxiliaries.
5. A quick shutdown stopping sequence shall be designed for quickly stopping the unit in the event of certain mechanical problems (86N trip). After the unit has come to a complete stop condition all the alarm conditions and the lockout relay(s) must be reset before the unit is ready for an automatic or manual system start. Safety circuits initiating a quick shutdown sequence shall be hardwired to a shutdown lockout relay. The stop sequencing shall include, but not be limited to, the following steps:
   a. Fast wicket gate closure.
   b. Turbine unloads to speed no load condition and trips the generator breaker and excitation off.

c. Generator thrust bearing high pressure lift pump on.
d. Generator brakes on at ~30% speed.
e. Unit at full stop.
f. Governor off.
g. Wicket gate lock on and shutdown unit auxiliaries.

6. An emergency shutdown stopping sequence shall be designed for rapidly stopping the unit in the event of certain mechanical or electrical or other emergency problems (86E trip). After the unit has come to a complete stop condition all the alarm conditions and the lockout relay(s) must be reset before the unit is ready for an automatic or manual system start. Safety circuits initiating an emergency shutdown sequence shall be hardwired to a shutdown lockout relay. The stop sequencing shall include, but not be limited to, the following steps:
   a. Fast wicket gate closure.
   b. Immediate trip of the generator breaker and excitation off.
   c. Generator thrust bearing high pressure lift pump on.
   d. Generator brakes on at ~30% speed.
   e. Unit at full stop.
   f. Governor off.
   g. Wicket gate lock on and shutdown unit auxiliaries.

C. Flow Control
1. Turbine Flow Control
   a. Once the unit is online the turbine-generator wicket gate position shall be automatically controlled based upon the flow set point. The controller shall automatically control the turbine wicket gates via the turbine governor controller to suite the flow requirements:
      (1) The water flow shall be maintained using a proportional-integral-differential (PID) type algorithm with water flow, and wicket gate position, input signals. The water flow preset value shall be able to be changed via the OIT.
      (2) Water flow shall be input from the penstock flow meter.
2. Turbine Shutoff Valve Control
   a. During normal operating conditions and turbine shutdown conditions the TSV shall remain open. The TSV shall automatically close during a turbine runaway condition, or during unit creep detection.

PART 2 - PRODUCTS

2.01 TURBINE AND GENERATOR CONTROL SWITCHBOARD CONSTRUCTION

A. The control switchboard shall be of the simple metal enclosed type consisting of stationary ~~front~~ rear, top and side panels with a hinged ~~rear~~ front mounted doors to allow access to the interior. The hinges for the doors shall be of the concealed type and shall allow the door to swing through not less than 105º from the closed position. Stops or restraining chains shall be provided to limit the swing and prevent damage to the hinges. The doors shall be furnished with a locking catch with keys removable in both the locked and unlocked position. Construction shall be indoor NEMA 12.

B. A continuous copper grounding bus bar not less than 1/4 inch by 1 inch shall be furnished

C. A LED lighting fixture(s), with on-off switch, shall be provided inside the switchboard and shall be suitably located to provide adequate interior lighting.

D. The control switchboard shall be equipped with a thermostatically controlled strip type space heater rated 120 volt, 1-phase, 60 Hz. The heater circuit shall be provided with a fused disconnect switch or circuit breaker.

E. The finish shall consist of a coat of air-dried enamel applied to clean and phosphatized steel for internal and external parts. Prior to shipment, the completed assemblies shall be given an exterior finish coat of gray enamel ANSI No. 61. The interior surfaces shall be finished white.

F. Nameplates

1. Furnish nameplates for instruments, relays, control switches, push buttons, indicating lights, and other items where the circuit and function of the device cannot be otherwise readily determined.
2. Nameplates shall be made of white plastic cut through to a black background. The lettering shall be of a size and design such that it will be legible from reasonable angles of observation and from distances of at least 10 feet.

G. Control Wiring

1. The control switchboard assembly shall be completely wired, and wires for connections to remote equipment shall be brought to terminal blocks. All wiring shall be neat and workmanlike, without splices and with a uniform arrangement of circuits. Wire bundles or single wires shall run in straight lines with 90º corners, where change of direction is required.
2. Switchboard wiring, inside the panel, shall be #16 AWG or larger. Wiring shall be UL type, SIS, or MTW, flexible stranded copper, control wire. Minimum conductor sizes shall be as follows:
   a. Current transformer circuits: #12 AWG minimum
   b. Potential transformer and control circuits: #14 AWG minimum
   c. Alarm circuits: #16 AWG minimum
   d. Instrument and communication circuits: #16 AWG minimum
3. Where possible wiring shall be run in plastic wire duct with covers. Where it is not possible to contain the wiring in the duct, the wiring shall be wrapped with plastic spiral binding. The plastic wire duct and spiral binding shall be as manufactured by the Panduit Company, Hoffman or approved equal.
4. Wire bundles crossing hinges shall be securely clamped to both the door and the panel, and run parallel to the hinge for at least half the door length to prevent chafing. No splicing shall be permitted in the wire duct or spiral wrapped wire bundles.

5. The wires connecting the various devices to each other and terminal blocks shall be labeled at both ends with destination codes. Wire labels shall be white heat shrink polyolefin sleeves with black lettering. Wire labels shall be Floy Tag & Manufacturing, Inc. Type FT-200S, or approved equal
6. Terminal blocks for control wiring shall be molded type, with barriers, rated not less than 300 volts, 25 amperes, suitable for conductors ranging between No. 22 and No. 14. White marking strips shall be provided with function codes (abbreviations indication function of the terminal point). Each connected terminal of each block shall have a function code placed on the marking strip with permanent marking fluid. Terminal blocks shall be Entrelec Type M 6/8.STP, or approved equal.
7. Terminal blocks for control power terminations shall be fused type with indicator. Fused terminal blocks shall be Entrelec Type MB 10/22.SFL with 13/32"x 1-1/2" fuse, or approved equal.

2.02 REMOTE PC WORKSTATION

A. A Remote PC workstation with minimum 24-inch monitor shall be provided in the existing control room to mimic the control and monitoring functionality for the Unit 4 main controller/HMI control switchboard.

B. Stratix Industrial Ethernet Switches shall be provided at the PC workstation end for network connectivity.

2.03 PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

A. The Master PLC and RTC PLC shall be modular type units with processor; power supply, communication modules, and I/O mounted in a multiple slot chassis. The PLCs shall be an Allen-Bradley ControlLogix 5000 series system or approved equal.

B. The PLC processors shall be furnished with sufficient memory; speed; and math and Proportional Integral Derivative (PID) instruction sets to meet the specified turbine and generator control and monitoring performance criteria. The processors shall utilize IEC 1131-3 compliant programming languages. The processors shall have an operating temperature range of 0º to +60ºC. The processors shall be an Allen-Bradley Type ControlLogix 5000 series, or approved equal.

C. The processors shall be equipped with battery-backed static RAM memory modules.

D. The processors shall support multi-tasking operations permitting multiple control tasks to operate independently within the same processor.

E. The PLC processors chassis and any required remote I/O chassis shall be furnished with adequately sized power supplies. The power supplies shall be rated for 24-volt dc, input with sufficient dc output to power all PLC processor and I/O requirements. The power supplies shall have an operating temperature range of 0º to +60ºC. The power supplies shall be powered from dc to dc power supplies powered from the station battery. The power supplies shall be Allen-Bradley Type 1756, or approved equal.

F. The PLCs shall be furnished with the proper input and output (I/O) modules for interfacing with the required external mechanical and electrical sensing devices. The I/O voltage, current, and isolation requirements shall match that of the external sensing devices. The I/O modules shall have an operating temperature range of 0º to +60ºC. I/O modules shall be Allen-Bradley Type 1756, or approved equal. I/O modules shall include but not be limited to:

1. Discrete input and output modules for interfacing with ac, dc and Transistor-Transistor-Logic (TTL) voltage levels. Modules shall be of 16-point density for ac voltage applications and 32-point high density for TTL voltage levels. Relay contact output modules shall be used for 125 V dc applications.
2. Analog input and output modules shall be high resolution, 16-bit for input modules and 14-bit for output modules. Modules shall be set up for 4-20 mA operation.
3. Resistance Temperature Detector (RTD) input modules for monitoring the generator winding and bearing RTD’s. Modules shall be set up for 100-ohm platinum type RTDs.

G. The PLCs shall be furnished with the required communication modules for communicating with the Ethernet local area network system and the various remote I/O devices. The communication modules shall be Prosoft, Allen-Bradley Type 1756, or approved equal.

H. The PLCs shall be furnished with communication modules for communicating between the Master PLC and the remote Workstation PC via a fiber optic communication link. The modules shall interface directly with the PLC I/O rack. The modules shall accept Ethernet I/P protocol over multimode fiber optic cable with straight tip (ST) type connectors. The modules shall be Phoenix Digital OCX, or equal.

2.04 OPERATOR INTERFACE TERMINAL (OIT)

A. The OITs shall be a full color Liquid Crystal Display (LCD) touchscreen display. Display size shall be a minimum of 19 inch (nineteen inch) diagonal. Information display shall be both graphical and tabular. The OITs shall be Allen-Bradley PanelView Plus 7, or approved equal.

B. The OITs shall conveniently allow operator control of all Unit manual and automatic functions, monitoring, and alarm response. Means shall be provided to enter setpoints and ramp rates via numeric keypad. Dedicated pushbuttons or keys shall be provided for Unit operation.

C. Development of the various monitoring, control, and trending screens shall be a joint effort between the Engineer and the Equipment Supplier. There shall be an initial scoping meeting and review meetings at 50%, 75%, and 100% design to finalize the OIT monitoring points, control parameters, and screen arrangements. The initial OIT screens shall be as follows:

1. Main Control Switchboard OIT

a. Overview: This screen shall display an overview of the Pine Flat Unit #4 systems. Overall system data such as generator output, flow metering, and TSV status shall be monitored from this screen.

b. Unit Master: These screens shall display the status for Unit #4 and its auxiliaries. These screens shall display the status of the turbine and generator and its auxiliaries including bearing, oil, water, air and winding temperatures. Turbine-generator control shall also be initiated via this screen.

c. Alarm Summary: This screen(s) shall display all the system alarms with time, date, type, and status data. This information shall be automatically backed up in a file and shall be printed out for troubleshooting purposes.

D. Alarms shall be indicated on the display. Alarm pages shall be provided for each major piece of equipment. Alarm presence shall be indicated on all screens.

2.05 CONTROL SWITCHBOARD INDICATING INSTRUMENTS

A. Switchboard instrumentation shall be furnished. All instrumentation shall be of the semi-flush mounted, back-connected, direct reading, switchboard type designed in accordance with ANSI C39.1, and with an accuracy rating within 1-percent of full-scale value. Instruments shall have a 3-1/2 or 5 digit, 7-segment, .56-inch red LED digital display unless otherwise specified and may display up to three functions simultaneously. Instrument cases shall be dust tight with antiglare faceplates. Power indicating instruments shall be Bitronics or equal. Position and level indicating instruments shall be Red Lion Controls IMP, or equal.

B. The indicating instruments shall include but not be limited to:

1. 3-phase varmeter
2. 3-phase wattmeter
3. Three voltmeters or one voltmeter and transfer switch
4. Three ammeters, or one ammeter and transfer switch
5. Frequency meter
6. Turbine wicket gate limit position digital display
7. Turbine wicket gate position digital display
8. RPM meter
9. Flow display
10. One synchronizing panel containing: 1-synchroscope (8-inch analog), 2-synchronizing lamps, 1-running voltmeter, and 1-running frequency meter. The synchronizing panel shall be visible to persons standing in front of the switchboard.

2.06 CONTROL SWITCHBOARD CONTROL SWITCHES

A. All control and instrument switches shall be of the rotary switchboard type with handles on the front and the operating mechanisms on the rear of the panel. Contacts of all switches shall be self-aligning and shall operate with wiping action. A positive means of maintaining high pressure on closed contacts shall be provided. The rear switch covers or plates shall be readily removable for inspection of contacts. Switches shall be Electro Switch Type 24, or equal.

B. The switch legend plates shall be engraved as shown on the Engineer approved Equipment Supplier Drawings.

C. The control and instrument switches shall include but not be limited to:

1. 2-position, maintained contact mode control switch engraved “Manual-Auto” shall be furnished.
2. 3-position, spring-return-to-center circuit breaker control switch engraved “Trip - Close” shall be furnished. The switch shall be furnished with a “Pull-to-Lock” feature for locking in the trip mode.
3. 3-position, spring-return-to-center wicket gate lock control switch engraved, “Off – On” shall be furnished.
4. 3-position, spring-return-to-center unit start/stop control switch engraved, “Stop – Start” shall be furnished.
5. 3-position, spring-return-to-center local generator brake control switch engraved, “Off – On” shall be furnished.
6. 2-position maintained contact manual synchronizing control switch engraved “Off-On” shall be furnished.
7. 3-position, spring-return-to-center raise-lower control switch engraved “Lower - Raise” shall be furnished for wicket gate adjust, wicket gate limit adjust, and voltage adjust.

2.07 PUSHBUTTONS

A. All pushbuttons shall be round, oiltight, heavy-duty type units. Pushbuttons shall be Allen-Bradley Type 800T, Cutler-Hammer, Square D Class 9001 Type K or approved equal.

B. The pushbutton legend plates shall be engraved as shown on the Engineer approved Equipment Supplier Drawings.

C. The control pushbuttons shall include but not be limited to:

1. Two pushbuttons labeled “Start”, and “Stop” for the thrust bearing high pressure oil pump.
2. Two pushbuttons labeled “Close”, “Open” for the turbine TSOV.

2.08 CONTROL SWITCHBOARD INDICATING LIGHTS

A. Indicating lamp assemblies shall be Light-Emitting Diode (LED), push-to-test assemblies of the switchboard type, suitable for 125V dc service, with appropriate color caps and integrally mounted resistors. The LED lamps shall be replaceable from the front of the panel. All color caps shall be interchangeable, and all LED lamps shall be of the same type and rating. The lamp assemblies shall be GE Type ET-16-LED or approved equal.

B. The lamp legend plates shall be engraved as shown on the Engineer approved Equipment Supplier Drawings.

C. The indicating lights shall include but not be limited to:

1. Generator circuit breaker position indicating lights: Red-Closed, Green-Tripped.
2. Wicket gate lock position indicating lights: Red-Off, Green-On.
3. Generator brake position indicating lights: Red-Applied, Green-Released.
4. Generator thrust bearing high pressure oil pump running lights: Red-On, Green Off.
5. TSV position indicating lights: Red-Fully Open, Green-Fully Closed.
6. Pre-start condition ready indicating light.
7. Auxiliaries started indicating light.
8. Unit starting indicating light.
9. Unit stopping indicating light
10. Unit online indicating light.
11. Unit stopped indicating light.

2.09 CONTROL SWITCHBOARD AUXILIARY RELAYS

A. Auxiliary control relays used for 125V dc control shall be vibration and shock resistant industrial type relays, and shall be rated for operation at 125V dc. Convertible type contact blocks rated for 125V dc operation shall be furnished. Auxiliary relays shall be Allen-Bradley 700 Type N, or equal.

B. Auxiliary control relays used for 120V ac or 24V dc control shall be vibration and shock resistant industrial type relays, and shall be rated for operation at 120V ac or 24V dc, as required. Auxiliary relays shall be Potter & Brumfield Type KUP, or equal.

2.10 CONTROL SWITCHBOARD POWER SUPPLIES

A. The power supplies for 24V dc requirements shall be switching type power supplies. The power supplies shall be rated for 105 to 145 volts dc input and 24 volts dc, output with +/-1% load regulation from 10% load to full load. The power supplies shall be Absopulse Electronics Ltd., or equal.

B. Redundant 24V dc power supplies shall be furnished. Failure of one power supply shall not interrupt 24V dc power to the PLC and auxiliary controls.

2.11 FIBER TO COPPER CONVERTER

A. A heavy duty industrial grade converters shall be furnished for converting the RS485 signals between the California ISO meter and the Owner's RTU for communication over the multimode fiber optic cable. The converters shall be B&B Electronics ELINX FOSTCDRi, or equal.

B. The converters shall include the following features and characteristics.

1. Multimode fiber.
2. ST type connector for multimode fiber connection.
3. Terminal block type connector for copper RS485 connection.

4. DIN rail mounting.
5. 24 V dc power requirement.

2.12 ETHERNET SWITCH

A. A heavy duty industrial rated Ethernet switch shall be provided. A suitable Allen Bradley Industrial Managed Ethernet switch or equal shall be provided.

B. The switch shall include the following features and characteristics.
   1. Conform to NEMA TS2 environmental requirements.
   2. Conform to IEC61000-6-2 EMC immunity for industrial environment.
   3. Six copper ports with RJ45 type connectors.
   4. DIN rail mounting.
   5. LEDs for power and link activity.
   6. 24 V dc power requirement.
   7. 96k bytes memory buffer.

2.13 FIBER PATCH PANEL

A. The patch panel shall include strain relief for the incoming fiber optic cables and single mode ST adapters for extension to communication devices.

B. Adjustable fiber management rings shall be furnished for storing fiber cable.

C. The panel shall be furnished with 12 single mode ST adapters.

D. Jumper cables shall be furnished for interconnection between the patch panel ST adapters and internal panel devices.
   1. Single mode jumper cables with molded polymer housing.
   2. ST type connector at each end with thermoplastic strain relief boot at connector.
   3. Each cable shall be 100% optically tested.

2.14 CONTROL SWITCHBOARD PROTECTIVE RELAYS

A. Generator Protection
   1. The generator protection relay system shall use a microprocessor based multifunction relay (MFR). The generator MFR shall be a Schweitzer Engineering Lab Model SEL-700G, or equal. The approved SEL model number is 700G11ACA2X7685A220 The relay shall, as a minimum, have the following features:
      a. Control power input of 125 V dc with redundant power supplies.
      b. Voltage input sensing from 60 V ac to 140 V ac, 60 Hz.
      c. Nominal current input sensing of 5.0 amp, 60 Hz. The current sensing input shall be able to withstand 10 amp continuous and 400 amp for 1-second.
      d. Output trip contacts rated per IEEE C37.90 for tripping duty.

e. Output alarm contacts.

f. A target display indicating the status of each of the relay protective functions.

g. Target storage, which shall include the last 32 targets with the following information: function operated, input/output contact status, time stamp, phase, and neutral currents at the time of trip.

h. A serial communication port for communicating with the OIT shall be provided. Communication shall also be furnished for interrogation and modification of setpoints and accessing the target storage information via a laptop PC.

i. The relay package shall include extensive self-testing with an alarm indication of a self-test warning or failure.

j. The generator protection relay package shall contain at a minimum the following protective features:

(1) Negative-sequence overcurrent (46)

(2) Reverse power (32)

(3) Backup protection with either dual zone phase distance protection (21) or with voltage restrained phase time-overcurrent protection (51V).

(4) Loss of excitation (40)

(5) Voltage transformer fuse-loss protection (60)

(6) Generator variable percentage phase current differential (87G)

(7) Over/under generator frequency (81 O/U)

(8) Over/under generator voltage (59/27)

(9) Overexcitation, volts/Hz, protection (24)

(10) 100% stator ground fault protection (59N/27N)

(11) Synchronize check relay (25) – To be used as unit synchronizer

B. Transformer Protection Relay

1. The Generator Step-up Transformer (GSU) protection relay system shall use a microprocessor based multifunction relay (MFR). The GSU MFR shall be a Schweitzer Engineering Lab Model SEL-487 or equal. The approved SEL model number is 487E3X411XXB4X4H5XXXXX The relay shall, as a minimum, have the following features:

a. Control power input of 125 V dc with redundant power supplies.

b. Voltage input sensing from 60 V ac to 140 V ac, 60 Hz.

c. Nominal current input sensing of 5.0 amp, 60 Hz. The current sensing input shall be able to withstand 10 amp continuous and 400 amp for 1-second.

d. Output trip contacts rated per IEEE C37.90 for tripping duty.

e. Output alarm contacts.

f. A target display indicating the status of each of the relay protective functions.

g. Target storage, which shall include the last 32 targets with the following information: function operated, input/output contact status, time stamp, phase, and neutral currents at the time of trip.

h. A serial communication port for communicating with the OIT shall be provided. Communication shall also be furnished for interrogation and modification of setpoints and accessing the target storage information via a laptop PC.

i. The relay package shall include extensive self-testing with an alarm indication of a self-test warning or failure.

j. The transformer protection relay package shall contain at a minimum the following protective features:

(1) Phase and Ground distance (21)

(2) Volts/Hertz (24)

(3) Over/under voltage (59/27)

(4) Transformer Differential (87)

(5) Over/under frequency (81 O/U)

(6) Directional Power (32)

(7) Directional Overcurrent (67)

(8) Neutral Overcurrent/ Neutral Time Overcurrent (50N/51N)

(9) Overcurrent/ Time Overcurrent (50/51)

(10) Current Unbalance (46)

(11) Breaker Failure Overcurrent (50BF)

C. Lock-Out Relays

1. The lock out relays (86) shall be electrically tripped, manually reset, high-speed multi-contact type with an operating time of approximately one cycle. In addition to the contacts required for protective circuit operation, two normally open and two normally closed contacts shall be furnished and wired to a terminal block for external use. Lock-out relays shall be Electro Switch Series 24 LOR, or equal. The following lock-out relays shall be furnished:

a. Normal shutdown lock-out (86N)

b. Emergency shutdown lock-out (86E)

D. Test Switches

1. Each of the protective relay assemblies shall be furnished with potential and current test switches, and test switches for each of the relay input and output function contacts. The test switches shall contain individual switches for isolating the input, output, potential and current circuits prior to inserting the test plug. The current switches shall automatically short-circuit the current transformers when opened. Each test switch shall be furnished with a test plug to permit testing the protective relay assembly from separate sources of potential and current. The test switches shall be ABB Flexitest Type FT-1, or approved equal.

2.15 WINDING AND BEARING TEMPERATURE MONITOR

A. Generator winding temperature monitoring shall be provided using the PLC and OIT. Provide PLC RTD type input channels for 100 ohm, 3-wire platinum dual element RTDs, one for each winding RTD plus 25% spare channels. The OIT shall display the temperature of each RTD. Adjustable PLC relay outputs shall be furnished for winding alarm and shutdown signals to the 86N lockout relay.

B. Generator and turbine bearing temperature monitoring shall be provided using the PLC and OIT Provide PLC RTD type input channels for 100 ohm, 3-wire platinum dual element RTDs, one for each bearing RTD plus 25% spare channels. The OIT shall display the temperature of each RTD. Adjustable PLC relay outputs shall be furnished for bearing alarm and shutdown signals to the 86N lockout relay.

C. The following winding and bearing temperatures shall be monitored for alarming and shutdown:

1. Two RTDs for each of the stator phase windings (6-total) of the generator shall be monitored with alarm & trip indication.
2. Two turbine guide bearing metal RTDs shall be monitored with alarm & trip indication.
3. Two generator upper guide bearing metal RTDs shall be monitored with alarm & trip indication.
4. One generator thrust bearing metal RTD for every shoe shall be monitored with alarm & trip indication.
5. One generator guide/thrust bearing oil RTD shall be monitored with alarm indication.
6. Two generator lower guide bearing metal RTDs shall be monitored with alarm & trip indication.
7. One generator lower guide bearing oil RTD shall be monitored with alarm indication.

2.16 SPARE PARTS

A. All spare parts shall be of the same material, workmanship, and manufacturer as the corresponding original parts, completely interchangeable and packaged for long-term storage.

B. Spare parts shall include the following:

1. Ten control power fuses for each size used
2. One LED push-to-test lamp for each type used
3. One 86 relay operating coil
4. One auxiliary control relay for each type used
5. One spare PLC CPU module
6. One spare PLC communication module for each type used
7. One spare PLC I/O module for each type used
8. One spare PLC power supply module for each type used

9.

PART 3 - EXECUTION

3.01 TESTING

A. Refer to Section 16360 – Control and Monitoring Systems Testing for shop and site testing requirements.

END OF SECTION

SECTION 16360
CONTROL AND MONITORING SYSTEMS TESTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

This section covers the requirements for factory and site testing of the control and monitoring systems for the Pine Flat Unit 4 Project.

1.02 SUBMITTALS

A. Refer to Section 01300 - Submittals for submittal requirements

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.01 FACTORY ACCEPTANCE TEST (FAT)

A. It is the responsibility of the Equipment Supplier to demonstrate that all components of the control and monitoring system meet the Owner and Engineer intent as set forth in these specifications and the Owner and Engineer approved Supplier system documentation.

B. Each of the individual system control panels shall be tested to confirm proper operation of all components associated with each individual system. The individual systems shall then be interconnected and tested as an integrated control and monitoring system. The Equipment Supplier shall develop a detailed FAT procedure document for review and approval by the Owner and Engineer prior to commencing with the FAT.

C. Unless otherwise notified, all testing shall be witnessed by the Owner and/or Engineer. The Equipment Supplier shall notify the Owner and Engineer, in writing, a minimum of 14 days before the FAT is to proceed. The FAT shall proceed based on the latest Owner and Engineer approved FAT procedure.

D. As a minimum, the step-by-step FAT procedure shall confirm the following:

1. Hardware components and assembly are in accordance with the specifications and the latest Owner and Engineer approved manufacturer drawings.
2. Software protocols for all external communication ports between the PLCs, OIT's, etc. are functional.
3. Databases are accurate and contain all the I/O points identified by the Equipment Supplier's latest Owner and Engineer approved documents.

4. Graphical displays are complete and functional.
5. All inputs and outputs are functional and properly calibrated.
6. Software operating control logic for the various systems complies with the requirements of the specifications and the latest Owner and Engineer approved Equipment Supplier documents.
7. Ethernet switch networks function correctly.

E. Wherever possible the actual field devices shall be used for simulating input and output control and monitoring functions. Where it is not possible to use the actual field device, analog and digital signals shall be used to simulate the field-mounted devices.

F. Appropriate sign off sheets shall be developed for each system tested. Variances shall be noted when the system fails to comply with the specification, or the latest Owner and Engineer approved Equipment Supplier documents. All variances shall be corrected at the factory, and the system retested, before the equipment is allowed to ship to the site.

G. The following control systems shall be tested:

1. Turbine Governor System
2. Turbine and Generator Control Switchboard
3. All signals from equipment under the Equipment Suppliers scope
4. All protection relays and auxiliary sub-components. All protection elements shall be tested with industry approved relay test equipment.
5. Complete Network.

H. A FAT report document shall be furnished after successful completion of all system testing. The report shall contain as a minimum the FAT procedures, system sign-off sheets, and a listing of all system and/or component variances corrected at the factory. No equipment shall ship until the FAT report is approved by the Owner and Engineer and all the variances are fixed.

3.02 SITE ACCEPTANCE TEST (SAT)

A. The SAT shall be a repeat of the FAT after the equipment has been installed and connected to the “real world” I/O devices including integration of the Turbine Generator equipment.

B. In general, the Owner’s personnel will operate all equipment during testing, including the SAT. Equipment Supplier will direct and supervise, and be responsible for, all actions of the Owner’s operating personnel during testing.

C. The Equipment Supplier shall develop a detailed SAT procedure document for review and approval by the Owner or Owner’s Engineer prior to commencing with the SAT. The test procedure shall include, but not be limited to, the following:

1. Dimension and finish checks
2. Assembly and installation checks against the manufacturer’s instructions
3. Equipment and software functional tests confirming proper operation of the PLC, OIT, and communication systems.

4. Protective device calibration and testing.
5. Operation and functionality test of all control modes and operator inputs.

D. Unless otherwise notified, all testing shall be witnessed by the Owner and Engineer. The Equipment Supplier shall notify the Owner and Engineer, in writing, a minimum of 14 days before the SAT is to proceed. The SAT shall proceed based on the latest Owner and Engineer approved SAT procedure.

E. Appropriate sign off sheets shall be developed for each system tested. Variances shall be noted when the system fails to comply with the specification, or the latest Owner and Engineer approved Equipment Supplier documents. All variances shall be corrected at the Equipment Supplier's expense, and the system retested, before the equipment is considered fully commissioned and ready for service.

F. The SAT shall include setting and calibration of all unit control switchboard protective relaying. The Equipment Supplier shall calibrate all the protective relaying with settings furnished by the Owner and Engineer.

G. All instruments and test equipment necessary for the complete inspection and testing shall be provided by the Equipment Supplier. Calibration certificates for instruments shall be furnished for Owner and Engineer approval and, if required by the Owner and Engineer, instruments shall be recalibrated before commencement of the tests.

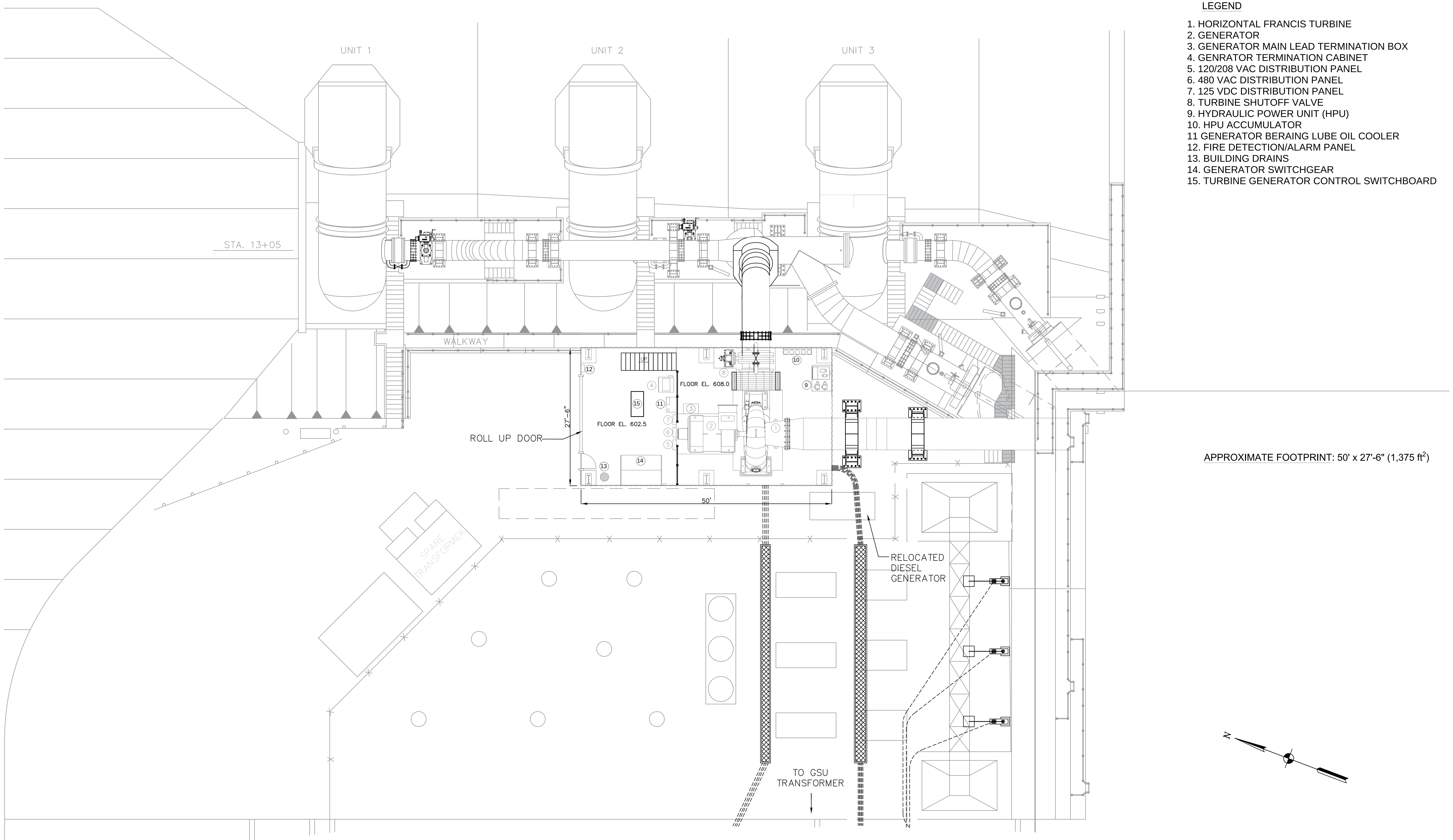
H. The Equipment Supplier shall furnish all special purpose tools and test apparatus essential for the test or repair.

I. Water and electric power for testing will be furnished by the Owner.

J. The Equipment Supplier shall not test, energize, or pressurize any equipment connected to existing equipment, or connected to equipment furnished by others, without approval from the Owner and Engineer. Before testing of any equipment connected to existing equipment, or connected to equipment furnished by others, or installed in areas where others may be working or assembled, the Equipment Supplier shall notify all others that such testing is about to commence and rope off any potentially dangerous areas with yellow "Caution" flagging.

K. A SAT report shall be furnished upon successful completion of all system testing. The report shall contain as a minimum the SAT procedures, test results of all systems, protective device settings, transmitter calibration data sheets, and turbine-generator no load and load testing data.

END OF SECTION



LEGEND

1. HORIZONTAL FRANCIS TURBINE
2. GENERATOR
3. GENERATOR MAIN LEAD TERMINATION BOX
4. GENRATOR TERMINATION CABINET
5. 120/208 VAC DISTRIBUTION PANEL
6. 480 VAC DISTRIBUTION PANEL
7. 125 VDC DISTRIBUTION PANEL
8. TURBINE SHUTOFF VALVE
9. HYDRAULIC POWER UNIT (HPU)
10. HPU ACCUMULATOR
11 GENERATOR BERAING LUBE OIL COOLER
12. FIRE DETECTION/ALARM PANEL
13. BUILDING DRAINS
14. GENERATOR SWITCHGEAR
15. TURBINE GENERATOR CONTROL SWITCHBOARD

APPROXIMATE FOOTPRINT: 50' x 27'-6" (1,375 ft^2)

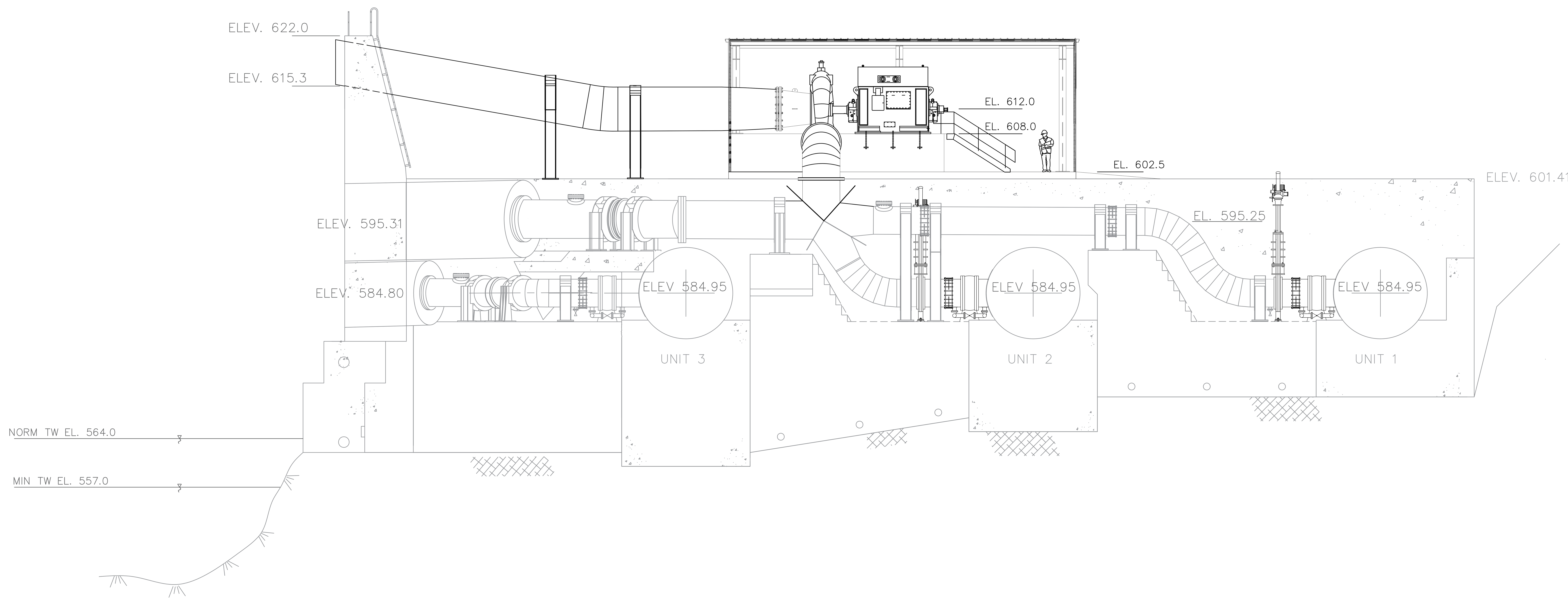
PLAN

NOTES:

1. CURRENT LAYOUT DISPLAYS TURBINE INLET INTERCONNECTED TO UNIT 1 AND UNIT 2 PENSTOCK ONLY. AN INTERCONNECTION TO UNIT 3 PENSTOCK MAY BE SUGGESTED FOR FINAL DESIGN.

REV	DATE	BY	DESCRIPTION	SCALE	WARNING					
				1"=10'	0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE	DESIGNED SPE DRAWN SPE CHECKED GM	PRELIMINARY POWERHOUSE LAYOUTS NOT FOR CONSTRUCTION	KRCD Kings River Conservation District Reliable resources for the Valley	Stantec	PINE FLAT POWERHOUSE PROPOSED SITE LAYOUT UNIT NO.4 POWERHOUSE SITE PLAN

SHEET G1
10509693



PROFILE

NOTES:
1. CURRENT LAYOUT DISPLAYS TURBINE INLET INTERCONNECTED TO UNIT 1 AND UNIT 2 PENSTOCK ONLY. AN INTERCONNECTION TO UNIT 3 PENSTOCK MAY BE SUGGESTED FOR FINAL DESIGN.

REV	DATE	BY	DESCRIPTION

SCALE 1"=8'

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED SPE
DRAWN SPE
CHECKED GM

PRELIMINARY POWERHOUSE LAYOUTS

NOT FOR CONSTRUCTION

KRCD Kings River Conservation District
Reliable resources for the Valley

Stantec

PINE FLAT POWERHOUSE

PROPOSED SITE LAYOUT
UNIT NO. 4 POWERHOUSE
ELEVATION VIEW

SHEET G2

10509693

TRANSVERSE SECTION

REV	DATE	BY	DESCRIPTION

SCALE 1"=6'

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED SPE
DRAWN SPE
CHECKED GM

PRELIMINARY POWERHOUSE LAYOUTS

NOT FOR CONSTRUCTION

KRCD Kings River Conservation District — Reliable resources for the Valley

Stantec

PINE FLAT POWERHOUSE

PROPOSED SITE LAYOUT
UNIT NO. 4 POWERHOUSE
TRANSVERSE SECTION

SHEET G3

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