FIJI ELECTRICITY AUTHORITY

TENDER DOCUMENTS FOR

Wailoa Mid-Life Refurbishment

Generator Rehabilitation

Contract No. MR 58/2016 June 2016

Fiji Electricity Authority

Wailoa Mid-Life Refurbishment

Generator Rehabilitation Specification

CONTENTS

1 Project Background

Wailoa Power Station is four unit station capable of generating 78.3MW, while the individual units operating on their own could originally produce up to 21.3MW at rated flow and maximum reservoir level. The station was finally commissioned in 1983.

Since the station was first commissioned, the conveyance system headloss have increased and the present peak output has reduced to 74MW.

The machines are typically operated at around 15MW per unit, occasionally a little higher. Wailoa is operated as a baseload facility and the aim of the rehabilitation is:

1. To extend the operational life of the existing plant by 30-40 years.
2. To improve the reliability of the plant.
3. To improve plant availability.
4. To bring the plant control, protection and monitoring in line with modern practices

According to FEA personnel the stator wedges were all replaced with ripple spring type a few years after commissioning. Around 1989 Unit 3 suffered a stator fault and a new coil was installed.

Problems have also been experienced with the field conductors shorting between the slip-rings and shaft. This is difficult to repair as the PMG/Exciter assembly must be removed to access the fault location.

Partial discharge measurements were made on all four units in 2007 and some evidence of corona was found at the same time during inspection. We understand that the machines were cleaned and semi-conductor paint applied to the area where the winding leaves the slot. No further corona has been observed. Wedge surveys are carried out every four years & a few loose wedges were identified on each machine during the previous survey.

PI measurements are also taken every four years and typically readings in excess of 3.3 are obtained.

Other contracts associated with the turbine generators will be proceeding in conjunction with this Contract. The Contractor is required to cooperate with the Employer and other contractors to help facilitate the smooth execution of the work.

The other contracts include:-

- Replacement of the 11kV circuit breakers;
- Refurbishment of the four existing turbines and governors.
- Refurbishment of the turbine inlet valves.
- Replacement of the tail race coolers and upgrade of the cooling water system
- Replacement of the individual Unit control panels;
- Provision of individual Unit PLCs to interface with all unit plant and provision of a station PLC to control all station related services and interface with the station, generator and transformer protection;
- Provision of new control systems and communications to the intake and surge chamber
- Provision of new excitation systems;
- Provision of penstock flow monitoring systems
- Numerous small works on the station

A number of other refurbishment projects have already been undertaken at the station including:-

- Replacement of the main 11/132kV step up transformers (completed 2013).
- Replacement of the electronic governors (completed 2012).
- Provision of a single new turbine inlet valve and provision of new hydraulic system to enable refurbishment of the existing valves (contract let 2015);

2 Conditions of Tendering

2.1 Scope of Tender

The Fiji Electricity Authority (FEA) invites Tenders for the refurbishment of four 24.5MVA hydro electric generators located at their Wailoa powerstation in Fiji.

The General Conditions of Contract pursuant to which the Contractor will provide the Works are based on FIDIC Conditions of Contract for Plant and Design Build for Electrical and Mechanical Plant and for Building and Engineering Works Designed by the Contractor, First Edition, 1999.

These Instructions comprise these instructions to tenderers together with all documents issued to tenderers in respect of the Works.

These Instructions do not constitute an offer, but are merely an invitation to the tenderer to submit a Tender.

All documents supplied by FEA remain the property of FEA. FEA reserves the right to request the immediate return of all documents supplied and any copies made of them at any time.

2.2 Delivery of Tenders

Two hard copies of the tender shall be submitted to the tender box located at the Supply Chain Office at the FEA Head Office in Suva by no later than 04.00pm (Fiji Time) on Wednesday, 03rd August,

Fiji Electricity Authority

2 Marlow Place

Suva

Fiji

Attention: Mr Tuvitu Delairewa

2.3 Tender Closing Time

Electronic copies of tender shall be uploaded onto the TenderLink website https://www.tenderlink.com/fea by no later than 04.00pm (Fiji Time) on Wednesday, 03rd August, 2016.
Hard copies can be received after the closing date and time provided the electronic copy is uploaded onto the TenderLink website and hard copy is despatched before the closing date and time as stipulated above. For any information and clarification please contact the General Manager Commercial, Mr Tuvitu Delairewa on email TDelairewa@fea.com.fj

2.4 Tender Validity

All Tenders shall remain open and valid for acceptance for a period of 60 days after the Tender Closing Time.

A Tender, once submitted, may only be varied by the tenderer with the prior written consent of FEA.

2.5 Identification of Tenders

Tender documents are to be delivered packaged and clearly identified.

2.6 Form of Letter of Tender

The form of Letter of Tender shall be as set out in Schedule 1, Tender Form 1.

2.7 Tender Documents

The tender documents comprise the following:

a) Section 1 – Background to the Contract
b) Section 2 – Tender Conditions
c) Section 3 - General Conditions of Contract
d) Section 4 - Particular Conditions of Contract
e) Sections 5, 6, 7, 8 – Specification
f) Tender Schedules

2.8 Information Required with Tender

Tenders shall include the name of the tenderer and a complete postal address for service of notices. Tenders shall include the following minimum information for evaluation:

- Fixed, lump sum tender price. All prices must be quoted in a single currency, nominated by the contractor plus Fijian dollars if required. The prices should excluding Fiji VAT and Withholding Tax and shall be deemed to include all direct, indirect and ancillary charges and costs for the Works;
- Statement of compliance with all Tender and Contract requirements.
- Completed tender forms;
- Confirmation of the full details of the refurbishment work proposed;
- Proposed programme for design, fabrication and on site works;
- Proposed key personnel;
- Any supplementary information required by the documents issued to the tenderers;
- Any interpretation or other statements by the tenderer affecting the Tender;
- The Tender shall be signed by or on behalf of the tenderer by a person with the delegated authority to do so. Written proof of the delegated authority to sign the tender offer may be requested.

2.9 Site Visit

The Tenderers shall arrange to visit the site by contacting the Engineer. A single visit will be arranged at a time that best suits the Employer, Engineer and bidders, tentatively during the week of 4 July 2016. The visit will include the opportunity to inspect one of the generators whilst shutdown. The generator will be fully assembled and no disassembly will be possible. Bidders should advise their preferred dates to the Engineer as soon as possible following receipt of the documents. . All site visits will be required to take place over the same one or two day period. Alternative dates will not be made available.

To register interest in a site visit contact:

Robin Spittle

MWH New Zealand Ltd

Telephone: +64 021 649402
Facsimile: +64 3 477 0616
Email: robin.d.spittle@mwhglobal.com

2.10 Evaluation of Tenders

Tenders received will be evaluated on the basis of such matters as FEA in its sole discretion determines are relevant, which may include the following:

- Quality of the solutions and plant offered and completeness of the offer.
- Tender sum and quoted rates and on-costs for possible approved variations.
- Proposed programme for the implementation and completion of the Works.
- Tenderer's experience, capability and commitment to achieving the project objectives.
- Tenderer's health and safety performance record and commitment.
- Compliance with the Contract conditions and specifications.

FEA may apply whatever weighting it considers in its sole discretion to be appropriate and the order set out above is not and shall not be taken to be the order of priority of the factors being considered by FEA.

2.11 Acceptance of Tender

FEA may, in its absolute discretion:

- Decline to consider any Tender;
- Reject all Tenders;
- Accept any Tender, notwithstanding that any other tender may propose a lower cost method of achieving FEA's objectives;
- Accept any Tender, even though it may not be in accordance with these Instructions.

FEA reserves the right to enter into negotiations with any unsuccessful tenderer or other party after the Tender Closing Time to complete the Contract.

2.12 Advice on Tender Outcome

All tenderers who submit a complying Tender will be notified of the outcome of the Tender. The advice will be limited to the name of the successful tenderer only if a Tender is accepted.

The successful tenderer will be invited by FEA to execute the Contract Agreement.

The original copies of all Tenders delivered to FEA will be the property of FEA and will not be returned to tenderers (unless FEA determines otherwise, in its absolute discretion).

2.13 Tender Enquiries

All enquiries relating to these Instructions shall be addressed to:

Tuvitu Delairewa

Fiji Electricity Authority

Phone: +679 999 2436

Email: TDelairewa@fea.com.fj

Any additional information, modifications or clarifications arising from enquiries from any tenderer will be confirmed in writing to all tenderers unless non-disclosure is necessary to protect tenderer confidentiality.

2.14 Communication

All communications regarding these Instructions may only be made to Tuvitu Delairewa. FEA will not be bound by any statement, written or verbal made by any person other than Tuvitu Delairewa, who is the only person authorised to make representations or explanations regarding these Instructions.

FEA may issue clarifications or changes to these Instructions by way of written Notice to Tenderers ("NTT") at any time prior to the Tender Closing Date. A copy of each NTT will be mailed or delivered to those who have received a copy of these Instructions. All NTTs issued will become part of this tender.

Where the Instructions are ambiguous or unclear to a tenderer, the tenderer may request the issue of an NTT for clarification. All such requests should be made in writing to Tuvitu Delairewa. A copy of each NTT issued will be mailed or delivered to those who have received a copy of these Instructions. All NTTs issued will become part of these Instructions.

In the absence of an NTT, Tenders may be submitted subject to any reasonable interpretation of any ambiguity or uncertainty in these Instructions, which shall be endorsed on the Tender.

2.15 Submission of Tenders

It is FEA's preference to contract on the basis set out in these Instructions. However, FEA may consider alternative Tenders. Any alternative Tender should clearly identify the commercial advantage and 'value added' offered.

By submitting a Tender, the tenderer confirms that FEA is authorised to:

- Verify with any third party any information included in the Tender or disclosed to FEA in connection with the tender;
- Discuss any matter relating to the tenderer or the tenderer's performance with any referee or other third party;
- Carry out a credit check on the tenderer and any proposed guarantor or other security provider.

The cost of preparing and submitting a Tender shall be borne by the tenderer

2.16 Tender Conditions

FEA reserves the right to:

- Suspend or cancel (in whole or in part) this tender process and/or overall process without assigning a reason;
- Terminate or exclude at any time participation by any tenderer in the tender process without assigning a reason;
- Call and/or re-advertise for tenders or revisit any tender process;
- Waive any irregularities or informalities in this tender process;

- Run the tender process as it sees fit, including by varying the process without assigning reason;
- Select suppliers based on their tender responses and/or invite them to participate in a further closed or open tender process;
- Issue Instructions with modified descriptions of goods/services requirements, including innovations identified and/or proposed FEA through this tender process;
- Enter into discussions and/or negotiations with one or more tenderers relating to matters dealt with in these Instructions;
- Deal separately with any of the divisible elements of any tender response, unless the relevant tender response specifically states that those elements must be taken collectively;
- Limit or extend the list of potential tenderers beyond those who respond to these Instructions;
- Seek clarification of any aspect or information provided in any tender response, and seek further information from any party;
- Consider, accept or reject any further Tenders (including any alternative or non-conforming Tenders) it may receive from any tenderer or other correspondent;
- Change any time, date or timeframe in, or any other aspect of, this tender process (including extending the closing date for the receipt of tender responses) by notice in writing to each tenderer;
- Liaise or treat with any prospective or actual tenderer at any time without necessarily liaising or treating with any other prospective or actual tenderer;
- Delete or change its requirements for any goods/services covered by this tender process;
- Conduct a financial check on any tenderer submitting a tender response; and
- Obtain similar goods/services from any third party and not deal exclusively with any tenderer under this tender process.

FEA will not be bound to give any reasons for decisions made as a result of the tender process or as an outcome of the Tender evaluations. Nothing contained or implied in these Instructions shall oblige FEA to discuss, justify or give reasons for any of its decisions or actions relating to these Instructions or any response.

Whilst FEA seeks to ensure that the supporting information contained in these Instructions and otherwise provided by or on behalf of FEA to the tenderer is accurate:

- FEA makes no representation or warranty, whether express or implied, as to the completeness, correctness or accuracy of such information; and
- Any drawings, reports or other material provided by or on behalf of FEA are provided for information purposes only and may not be relied upon as constituting accurate information.
- The tenderer is to make its own enquiries as it considers necessary before relying on any information provided by FEA and before submitting its Tender. FEA shall have no liability for any inaccuracies, errors, omissions or mistakes in such documentation.

Those submitting tender responses will be deemed to have:

- Examined these Instructions and all documents referenced (if any);
- Considered all the risks, contingencies and other circumstances that may have an effect on their tender responses;
- The Tenderer will be deemed to have visited the site and satisfied themselves that the offer is complete. On site conditions will not be accepted as a reason for variation at a later date.
- Taken into account all restrictions, procedures, costs, timings and potential difficulties which may affect the performance of the Works; and
- Satisfied themselves as to the correctness and sufficiency of their tender responses, including the pricing structure offered.

All tenderers submitting a Tender agree that:

- A contract is only formed between FEA and the successful tenderer when FEA executes the Contract Agreement, setting out in full the terms upon which FEA has engaged that tenderer to carry out the Works;
- These Instructions, and any provision contained herein, do not give rise to a separate contract between FEA and the tenderer; and
- Nothing in these Instructions, or in the relationship of FEA and the tenderer, imposes any duty of care on FEA, and any such duty of care is expressly excluded.
- All costs incurred by the tenderer in connection with its Tender, these Instructions or any related matters are the sole responsibility of the tenderer.

2.17 Tender Responses

Each tenderer must include the information as required by FEA in these Instructions. Information not specifically required by these Instructions, but believed by the tenderer to be of value in evaluating the responses, should be included as an addendum. Where there is reference to published manuals, only the relevant extracts should be placed in the addendum.

All tenderers warrant that:

- All information provided in their response is complete and accurate in all material respects;
- Provision of information to FEA, and the use of it by its employees, agents or contractors for the evaluation of responses and the possible subsequent negotiation and implementation of a contract, will not breach any third party's intellectual property rights; and
- FEA is under no obligation to check any tender response for errors. Acceptance of a tender response that contains errors will not invalidate any contract that may be negotiated on the basis of that tender response.
- Tenderers must not, without FEA's prior written consent, consult, communicate or agree with any other tenderer in connection with any Tender, and shall not make any attempt to influence any other tenderer to submit or not submit a Tender or to alter the proposed content of that tenderer's Tender.

2.18 Confidentiality

These Instructions, all information supplied by FEA (either itself or through its consultants or advisors) in connection with these Instructions and all discussions relating to these Instructions, are confidential. Tenderers must not release or disclose any of the information or discussions to any other person (other than the tenderer's employees or advisors on a need to know basis) without the prior written consent of FEA.

All drawings and documents of the existing works included in these tender documents are provided for the sole purpose of enabling Tenders to submit to the Employer proposals to rehabilitate the works. Unsuccessful Tenderers shall destroy all such drawings and documents following notification of award to another party. Any use of the drawings and documents by a Tenderer, other than for the purposes of assisting the Employer in rehabilitating the works, may breach the original manufacturer's copyright and the Tenderers shall indemnify the Employer and Engineer against the costs of any claim or defending any such claims that may arise from such breach of copyright by the Tenderer.

2.19 Preferred Tenderer

Should a tenderer be informed that they are a preferred tenderer, such advice does not:

- Constitute an acceptance by FEA nor create a contract;
- Constitute an award of the contract; nor
- Imply or create an obligation on FEA to enter into negotiations with or award the contract to the tenderer.

FEA reserves the right to discontinue negotiations at any time.

2.20 Acknowledgement by Tenderer

Each tenderer acknowledges that FEA has reserved to itself certain rights and discretions in these Instructions and agrees that it assumes, at its sole cost, the risk that FEA may at any time exercise any of these rights and discretions. Each tenderer agrees that it shall not have any rights, and further waives any rights it may have, against FEA or any other person arising from the exercise by FEA of its rights and discretions, and agrees not to make any claim, bring any action or otherwise seek to recover from FEA any costs incurred by that tenderer in respect of its Tender or any lost expectation of profits or other benefits which that tenderer may expect to accrue to it from acceptance of its Tender.

2.21 Governing Law

These Instructions shall be construed according to and governed by Republic of the Fiji Islands Law and the tenderers agree to submit to the non-exclusive jurisdiction of the Fijian Courts in any dispute or difference of any kind which may arise concerning the same.

3 General Conditions of Contract

3.1 Preamble

The General Conditions of Contract pursuant to which the Contractor shall provide the Works will be the "FIDIC - Conditions of Contract for Plant and Design-Build for Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor", First Edition, 1999.

All capitalised terms in this section of the documents are as defined in The General Conditions of Contract unless the context requires otherwise or unless amended by the Particular Conditions of Contract.

References to Sub Clauses in this section are references to Sub Clauses in the General Conditions of Contract.

The Employer: Sub Clause 1.1.2.2

The Employer is: Fiji Electricity Authority
Private Mail Bag
2 Marlow St
Suva
FIJI ISLANDS

The Employer's Representative is: Eparama Tawake
General Manager - Generation

The Contractor: Sub Clause 1.1.2.3

The Contractor is:

Telephone:

Facsimile:

Email:

The Engineer: Sub Clause 1.1.2.4

The Engineer is: Robin Spittle
MWH New Zealand Ltd
PO Box 4
265 Princes St
Dunedin

NEW ZEALAND

Telephone: +64 021 649402
Facsimile: +64 4 477 0616
Email: robin.d.spittle@mwhglobal.com

The Engineer's Representative: Sub Clause 3.2

The Engineer's Representative is: Robin Spittle
MWH New Zealand Ltd
PO Box 4
265 Princes St
Dunedin
NEW ZEALAND

Telephone: +64 021 649402
Facsimile: +64 4 477 0616
Email: robin.d.spittle@mwhglobal.com

Time for Completion: Sub Clause 1.1.3.3

Section 1: 417 days
Section 2: 261 days
Section 3: 372 days
Section 4: 274 days

Defects Notification Period: Sub Clause 1.1.3.7

365 Days for each of Sections 1, 2, 3 and 4 of the Contract.

Contract Sections: Sub Clause 1.1.5.6

There are four separate Sections

Section 1: Design, manufacture, transport, refurbishment, site installation commissioning and testing of Unit 4 generator and all associated auxiliaries.

Section 2: Design, manufacture, transport, refurbishment, site installation commissioning and testing of Unit 2 generator and all associated auxiliaries.

Section 3: Design, manufacture, transport, refurbishment, site installation commissioning and testing of Unit 1 generator and all associated auxiliaries.

Section 4: Design, manufacture, transport, refurbishment, site installation commissioning and testing of Unit 3 generator and all associated auxiliaries.

Section 2, 3 and Section 4 may proceed with an altered scope of work depending on the outcomes of the Section 1 works.

Each Separate Section shall be a standalone Section of the contract with its own Taking Over, Certificate of Acceptance, Defects Liability Period and Performance Certificate.

The following applies

a) The Employer reserves the right to change the order in which each generator is refurbished.
b) Only one turbine generator unit can be out of service at any time.

Electronic Transmissions: Sub Clause 1.3

Electronic transmissions shall be by email. Drawings shall be transmitted as AutoCAD drawing files and PDF files. Spreadsheets shall be transmitted as Microsoft Excel files or PDF files. Typed documents shall be transmitted as Microsoft Word files or PDF files. The PDF files shall be created using Adobe software.

Governing Law: Sub Clause 1.4

The Contract shall be governed and take effect in accordance with the laws of the Republic of Fiji and any arbitration shall be governed by such laws. The parties hereto submit to the non-exclusive jurisdiction of the Fiji Courts.

Ruling Language: Sub Clause 1.4

English

Language for Communications: Sub Clause 1.4

The language for all communications is English.

Time for Access to the Site: Sub Clause 2.1

The Employer shall give the Contractor right of access to, and non-exclusive possession of, each part of the Site on or before the possession dates shown in the latest approved programme. Refer to clause 3.3 of Preliminary and General Section of this Contract for the preliminary programme.

Engineer's Duties and Authority Sub Clause 3.1

The Engineer must obtain approval from the Employer for any Variation that increases the Contract Price.

Performance Security Sub Clause 4.2

10% of the Accepted Contract Amount for all Sections of the Contract up to Taking Over of the final refurbished Generator covered under the contract. This shall reduce to 5% during the Defects Notification Period for the final refurbished Generator.

Employer's Equipment: Sub Clause 4.20

None to be provided. The exception is the powerhouse crane and any special tools available for the maintenance of the existing generators and their auxiliaries.

Period for Notifying Unforeseeable Errors, Faults and Defects in the Specification: Sub Clause 5.1

14 days after Commencement Date.

Working Hours Sub Clause 6.5

Working hours shall be between 7am and 10pm unless otherwise approved by the Employer.

Commencement of Work Sub Clause 8.1

The Commencement dates for each Section of the works are:

Section 1: Date of the Letter of Acceptance.

Section 2: Date of Taking Over of Section 1

Section 3: Date of Taking Over of Section 1

Section 4: Later of the Date of Taking Over of Section 2 and Section 3

Delay Damages Sub Clause 8.7

0.5% of the value of the Section of the Contract per day, up to a maximum of 10% of the Contract value

Provisional Sums Sub Clause 13.5

A Provisional Sum of USD$200,000 shall be included.

Adjustments for Changes in Cost Sub Clause 13.8

The Contractor shall propose a method for adjusting for any changes in cost over the time the Works under the Contract are being carried out. The agreed method for adjusting the cost during the duration of the Contract will be set out in the Letter of Acceptance. No cost increase will be allowed for delays in completion of any of the Sections of Work or for the effect of a delay in one Section of the Work on subsequent Sections of Work.

Advance Payment Sub Clause 14.2

10% advance payment will be provided for each of Sections 1 to 4. The payment will be due within 14 days of the Commencement Date for each Section.

Percentage of Retentions: Sub Clause 14.3

The Percentage of Retentions shall be 25%, reducing to 10% on completion of Installation and Commissioning and 0% on Taking Over.

Delayed Payment: Sub Clause 14.8

The interest rate for delayed payment shall be at the Westpac Banking Corporation of Fiji base commercial overdraft rate applicable at the time of the delayed payment plus 1.8% per annum.

Currencies of Payment: Sub Clause 14.15

Payments can be claimed in Fiji dollars plus a single nominated currency. Australian, New Zealand, Euro and US currency are permitted. Other international currencies will be considered. The maximum amount owing in each currency must be nominated at time of tender

The rate of exchange between currencies shall be the sell rate quoted by the Westpac Banking Corporation of Fiji at the Base Date.

Period for Submission of Insurance: Sub Clause 18.1

(a) evidence of insurance: within 28 days of the acceptance of contract.

(b) relevant policies: Within 28 days of the acceptance of contract.

Maximum Amount of Deductibles For Insurance of Employer's Risks: Sub Clause 18.2(d)

US$50,000

Minimum Amount of Public Liability Insurance: Sub Clause 18.3

US$10,000,000

Minimum Amount of Professional Indemnity Insurance: Sub Clause 18.5

Value of the Works plus 20%

Motor Vehicle Third Party Insurance: Sub Clause 18.6

US$1,000,000

The DAB shall be: Sub Clauses 20.2

There is no DAB. Refer to the Particular Conditions Clauses 20.2 to 20.4

4 Particular Conditions of Contract

The following Particular Conditions of Contract amend or modify or are in addition to the General Conditions of Contract.

4.1 Definitions

References to Sub Clauses in this section are references to Sub Clauses in the General Conditions of Contract.

1.1.1.1	*second line, replace* “Employer’s Requirements” *with* “Specification”.
1.1.1.5	*delete and substitute:* “Employer’s Requirements” means the purpose, scope, design requirements and technical data contained in the Specification.
1.1.2.2	*delete and substitute: “Employer” means Fiji Electricity Authority, its assignees and any legal successors in title to Fiji Electricity Authority.*
1.1.2.8	*delete and substitute: “Engineer” means MWH New Zealand Ltd, its assignees and any legal successors in title to MWH New Zealand Ltd.* *add “and includes a Nominated Subcontractor" after "Works" on line 3*
1.1.3.3	*delete. There is no Dispute Adjudication Board* *replace “Appendix to Tender” with “Preamble”*
Add new Sub Clause:	
1.1.3.10	"Acceptance Certificate" means the certificate to be issued by the Engineer to the Contractor pursuant to clause 12.5."
1.1.5.6	*replace* “Appendix to Tender” *with* “Preamble”.
Add new Sub Clauses:	
1.1.6.10	“Specification” means Sections 5, 6, 7, 8, 9 and 10 of the Contract and the Common Requirements Section of the Contract.

4.2 Changes and Additions to the General Conditions of Contract

References to Sub Clauses in this section are references to Sub Clauses in the General Conditions of Contract.

1 The Contract

1.3 Communications

In (a) *and* (b) *replace* "Appendix to Tender" *with* "Preamble".

1.4 Law and Language

replace "Appendix to Tender" *with* "Preamble" where it appears throughout this Sub Clause.

1.5 Priority of Documents

Delete and substitute:

The documents forming the Contract shall be taken as mutually explanatory of one another. For the purposes of interpretation, the priority of documents from highest to lowest shall be in accordance with the following sequence:

(a) Contract Agreement;

(b) Letter of Acceptance;

(d) Preamble;

(e) Completed Tender Schedules;

(f) Notice to Tenderers (NTT);

(g) Particular Conditions;

(h) General Conditions;

(i) Specification;

(j) Letter of Tender;

(k) Contractor's Proposal;

(l) Instructions to Tenderers.

1.7 Assignment

Delete and substitute:

"The Contractor shall not assign the whole or any part of the Contract or any benefit or interest in or under the Contract. However, the Contractor may:

(a) Assign the whole or any part of the Contract with the prior agreement of the Employer, at the sole discretion of the Employer, and

(b) As security in favour of a bank or financial institution, assign its right to any moneys due, or to become due, under the Contract.

The Employer shall be free to assign the whole or any part of the Contract or any benefit or interest in or under the Contract."

1.8 Care and Supply of Documents

First paragraph, replace "six" *with* "three".

Second paragraph, replace "Employer's Requirements" *with* "Specification".

1.12 Confidential Details

Add the following:

"The Contractor shall treat the details of the Contract and the Works as private and confidential except to the extent necessary to carry out obligations under the Contract or to comply with applicable Laws. The Contractor shall not publish, permit to be published or disclose any particulars of the Works in any trade or technical paper or elsewhere without the prior agreement of the Employer."

"The Contractor is required to disclose to the Engineer or the Employer confidential information to allow:

(a) The Plant and the Works to be fully integrated with existing systems and operated and maintained in the correct manner; and

(b) The Employer or the Engineer to confirm the full compliance with the Specification.

2 The Employer

2.1 Right of Access to the Site

Insert the words "Subject to Sub-Clause 4.15 (Access Route)" *at the beginning of the first paragraph.*

First paragraph delete "Appendix to Tender" *and substitute* "Preamble".

Second paragraph delete "Appendix to Tender" *and substitute* "Preamble".

3 The Engineer

3.1 Engineer's Duties and Authority

Third paragraph, second sentence, delete "Particular Conditions" *and substitute "Preamble".*

4 The Contractor

4.1 Contractor's General Obligations

In line 4 of the last paragraph delete the words "to the Engineer" *and insert* "and approved by the Engineer. No refusal by the Engineer to such alterations shall give rise to a claim for a Variation, extension of time, cost or profit."

Add the following at the end of the Sub Clause:

The Contractor agrees that if at any time during the performance of the Works the Contractor is of the opinion that a change in the design or execution of the Works:

(a) is necessary to eliminate a potential defect in the Works or a specific hazard to any person in the performance or operation of the Works; or

(b) would otherwise be beneficial to the Employer (whether by maximising the efficiency or cost effectiveness of the construction, operation and maintenance of the Works or otherwise);

then the Contractor shall bring the matter to the attention of the Engineer in writing and the Engineer shall determine whether Clause 13 [Variations and Adjustments] shall be applied and shall notify the Contractor accordingly.

4.2 Performance Security

Delete the first paragraph and substitute:

The Contractor shall provide the Employer with Performance Security in the form of an unconditional on demand bond to secure performance of the Contractor's obligations under the Contract Agreement. The Performance Security shall be for the amount stated in the Preamble. The Performance Security shall be provided as an irrevocable bond provided by a surety which shall be a registered bank in Fiji, New Zealand or Australia or such other jurisdiction as approved by the Employer.

Add the following to the end of the Sub Clause:

If the Performance Security is not delivered to the Employer within the required time or at any time ceases to be valid and enforceable (except in the circumstances expressly permitted in the contract), or the surety providing the Performance Security becomes, in the reasonable opinion of the Employer, no longer acceptable credit support then the Employer shall be entitled to:

(a) suspend the contract until the Performance Security (or an acceptable replacement, as the case may be) is delivered to the Employer. Such suspension shall not be treated as a Variation and the Contractor shall not be entitled to any extensions of time or any compensation as a result of such suspension;

(b) withhold any payments due to the Contractor until the Performance Security (or an acceptable replacement, as the case may be) is delivered to the Employer. The Contractor shall not be entitled to make any claims against the Employer by reason of any such withholding of payments; and/or

(c) without limiting the foregoing, treat such failure as a default by the Contractor under Sub Clause 15.2.

Following consultation with the Contractor, where the Employer gives reasons for its view, the Employer shall be entitled to require the Performance Security to be replaced by another form of security acceptable to the Employer if it reasonably forms the view at any time that the validity or enforceability of the Performance Security or credit-worthiness of the surety providing the Performance Security may be in question. The Contractor shall, within 14 days after receipt of the Employer's request for the Performance Security to be replaced, procure the replacement Performance Security and deliver the same to the Employer within the 14 day period. The Employer shall release a replaced Performance Security within 14 days of receiving the replacement Performance Security from the Contractor, provided that should there be any unpaid claims on such replaced Performance Security, the Employer shall not be required to release it until such claims have been paid in full.

4.5 Nominated

Add the following as a second paragraph:

Subcontractors

"Where such notice of objection is given to the Engineer and the matter is not resolved within a reasonable time the Employer or the Engineer shall make a fresh nomination of a Subcontractor. Alternatively the Engineer and the Contractor may agree to the work being carried out by the Contractor or by another Subcontractor or by some other contractor under a separate contract with the Employer."

4.16 Transport of Goods

Add the following:

"Any packing used shall prevent mechanical damage to the contents. It shall also prevent the ingress of water. Desiccants shall be included in each waterproof package. Each package shall be clearly labelled with its contents, drawing reference, destination, handling requirements and weight.

Packing of any Plant or Materials shipped from overseas shall comply with The Fiji Islands import regulations. The Contractor shall certify, with the notice provided under (a) above that no prohibited materials have been used for packing. The Contractor shall be responsible for any fumigation costs or other costs resulting from packing that does not comply with The Fiji Islands import regulations.

The Contractor shall not bring any Goods onto the Site unless and until the time they are to be incorporated into the Works.

All Goods when incorporated into the Works shall be free from all charges, encumbrances or liens.

4.18 Protection of the Environment

Delete the second paragraph and substitute:

"The Contractor shall ensure that all activities and operations under the Contract comply with all applicable Laws, and all applicable the environmental requirements for the Works"

Add the following at the end of the Sub Clause:

In carrying out the Works, the Contractor shall not do anything or omit to do anything, or use materials, substances or processes which:

(a) might discharge a contaminant into the environment, cause the emission of noise to exceed such levels, or cause any adverse effect on the environment, which would constitute a breach of the environmental approvals applicable to the Works or the Site;

(b) is a breach of any duty or obligation of the Employer; or

© is a breach of any of the environmental approvals applicable to the Works or the Site or causes the Employer to breach any such approvals for Works on the site; or

4.22 Security of the Site

Add to the end of paragraph (a):

"The Contractor shall advise the Engineer if the Contractor is aware of unauthorised persons on the Site."

5 Design

5.1 General Design

Third paragraph, second sentence, delete "Appendix to Tender"

Obligations

and substitute: "Preamble"

Add at the end of the Sub Clause:

Without limiting the foregoing, the Contractor must ensure that the Plant, Materials and the Works are professionally designed to be appropriate and fit for the purposes for which the Works are intended as defined in the Contract and which meet the technical specifications, design life and the performance requirements set out in the Specifications and the Contractor's Tender.

5.9 Additional Design Issues

Add new Sub Clause 5.9:

"The Contractor agrees to accept all responsibility and meet all costs for developing all aspects of the design required by the Specifications and to produce detailed plans and specifications.

The Specifications include preliminary plans and specifications that describe the scope, requirements and expectations of the Employer in respect of the Works and their operation. The Contractor acknowledges in this regard that:

(a) The Specifications are a guide only and do not cover all items of work required to provide the Works; and

(b) The Employer accepts no responsibility for the completeness or accuracy of the design, plans, drawings and specifications described in the Specifications.

The Contractor shall develop the design described in the Specifications into a concept design and a detailed design (which for the purposes of this Sub Clause 5.9 are the *designs*). The content of the designs shall be as described in the Specifications.

The Contractor shall certify to the Employer that the designs comply with at least the minimum requirements and expectations of the Employer in respect of the undertaking and performance of the Works as described in the Specifications.

The Contractor shall submit the designs to the Engineer for review on the dates specified in the Specifications, and shall undertake any factory or Site testing as required by the Specifications and supply the test results to the Engineer.

Except where the Contract otherwise provides:

(a) The Engineer shall not be required to check the designs for errors, omissions, inconsistencies, ambiguities, discrepancies or compliance with the Contract.

(b) Any acknowledgement, comment, or approval of the designs by the Engineer shall not prejudice or affect the Contractor's obligations to complete the Works in strict compliance with the Contract

(c) If errors, omissions, inconsistencies, inadequacies or other defects are found in the designs, the designs and the Works shall be corrected at the Contractor's cost, notwithstanding any consent or approval given by the Engineer.

5.10 Design Responsibility

Except where the Contract otherwise provides:

(a) The Contractor is responsible for the design of all

Scope.

modifications to the existing generator and its auxiliaries and for the refurbishment works provided under this Contract. The Contractor is also responsible reporting to the Engineer any deficiencies in the design of equipment provided by the Employer that is being retained

(b) The Contractor is not responsible for the design of the existing generator that is not being modified under the Contract.

5.11 Technical Standards and Regulations

Add New Clause 5.11

Wherever reference is made in the Contract to specific standards and codes to be met by the Materials, Plant, and other Goods to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the Contract. Where such standards and codes are national, or relate to a particular country or region, other authoritative standards that ensure substantial equivalence to the standards and codes specified will be accepted subject to the Engineer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event the Engineer determines that such proposed deviations do not ensure substantially equal performance, the Contractor shall comply with the standards specified in the documents.

Notwithstanding the above, the Fiji National Building Code shall be applied to any building works. The Fiji Electricity Regulations Cap 180 Regulations 45, 46 and 47 shall apply to all elements the Works.

6 Staff and Labour

6.5 Working Hours

Add the following:

"The normal working hours in respect of those parts of the Site owned by the Employer are restricted (if at all) to the extent specified in the Preamble. The Contractor acknowledges that where any part of the Works is to be carried out on parts of the Site not owned by the Employer, the Contractor will be required to comply with any restrictions on working hours put in place by the owner of the Site."

Replace "Appendix to Tender" *with* "Preamble" (being paragraph 1.2 of this document).

Insert the following at the end of the Sub Clause:

"Any works undertaken pursuant to the above shall not entitle the Contractor to additional costs, unless such work is undertaken pursuant to a Variation."

6.7 Health and Safety

Delete and substitute:

"The Contractor, in its capacity as an employer and a person in control of a place of work, shall ensure that its employees, any other persons in the workplace and people in the vicinity of the

workplace, are not harmed by any workplace hazard. The Contractor shall comply with health & safety requirements for Site, the Contractor's health and safety plans and its obligations under the Fiji Health and Safety at Work Act 1996 including subsequent amendments (including all regulations and, where appropriate, Codes of Practice made under the Act), and the Electricity Regulations and any other legal and statutory safety obligations in relation to ensuring the safety of its employees, hazard management, information for employees and training and supervision of employees, and any other statutory safety obligations.

The Contractor, in its capacity as an Employer and a person in control of a place of work, shall ensure that its employees, Subcontractors, and any other persons on the Site and in the vicinity of the Site for whom it is responsible, are informed of existing Site specific hazards, emergency and other requirements and the Employer's expectations and requirements as regards health and safety, all as set out in the Specification or advised from time to time by the Engineer. The Engineer shall notify the Contractor of all of the Employer's key personnel at the workplace and their contact details for accident and other reporting purposes.

The Contractor shall immediately notify the Engineer in writing of any hazard the Contractor identifies on the Site, the date the hazard was identified, and the steps taken to eliminate, isolate, minimise and monitor the hazard.

The Contractor shall have and comply with its own appropriate Site specific safety and health plan which shall ensure all relevant places of work are safe, that hazards are controlled and that compliance with all health and safety laws is achieved. The Contractor shall submit its project specific safety and health plan to the Engineer at least 14 days prior to commencing any work on the Site. The Contractor shall review the plan regularly and shall ensure that it is maintained so as to be up to date and fully compliant with all Laws.

The Contractor shall comply with any health and safety plans currently implemented on the Site. Failure to comply with existing health and safety plans may result in the Engineer instructing the Contractor to cease or not commence furnishing the Works or part of the Works until the Contractor complies with its health and safety obligations required pursuant to this Contract. Any such instruction shall not constitute a Variation and the Contractor shall not be entitled to any extensions of time or any compensation as a result of such instruction.

The Engineer may audit the Contractor from time to time on any aspect of its activities or procedures as they relate to safety and health. If the Engineer is of the opinion that the Contractor has failed to comply with any part of this Sub Clause the Engineer may advise the Contractor and may instruct the Contractor to cease or not commence furnishing the Works or part of the Works until the Contractor complies with its health and safety obligations required pursuant to this Contract. Any such instruction shall not constitute a Variation and the Contractor shall not be entitled to any extensions of time or any compensation as a result of such instruction.

If any employee of the Contractor or any Subcontractor suffers an injury while furnishing the Works which results in the employee's death or inability to work for any part of the next day or shift scheduled for work, the Contractor shall inform the Engineer forthwith and as soon as practicable shall provide details on the Employer's standard "Event Report" form.

For statistical purposes, the Contractor shall provide in writing, with each monthly progress report, the total hours worked during the previous month on the Site by its staff and also separately by its Subcontractors. Staff shall include supervisory and administrative staff. The Contractor shall maintain records and make reports concerning health, safety and welfare of persons, and damage to property, as the Engineer may reasonably require.

The Contractor shall also comply with any safety provisions included in the Specification."

6.9 Contractor's Personnel

Add the following:

"The Contractor shall employ the key personnel named in the Tender to fill the positions stated in the Tender, or, where it is unable to do so, shall employ others approved by the Engineer pursuant to this Sub Clause 6.9".

The Contractor shall not without the prior consent of the Engineer replace any of the approved key personnel.

The Engineer shall not be required to approve a proposed replacement key person unless such person's relevant qualifications and experience are at least as good as those of the person who is to be replaced. Otherwise, the Employer's approval to any proposed replacement key person shall not be unreasonably withheld".

7 Plant, Materials and Workmanship

7.1 Manner of Execution

Add to the end of Sub-Clause 7.1

Unless otherwise specified in the Contract, all Materials used other than Temporary Works shall be new.

The Contractor expressly acknowledges that the Employer entered into the Contract in reliance upon:

(a) the skill and judgement of the Contractor as a designer, manufacturer, fabricator, supplier, installer, erector, constructor, tester and commissioner of facilities of the size, nature and standard of the Works; and

(b) the ability of the Contractor to design, manufacture, construct, fabricate, supply, install, erect, test and commission the Works with the highest regard to the environment and to the safety of workers and all other persons at or in the vicinity of the site, the Works and the property of third parties.

Add new Sub-Clause 7.1(d)

The Contractor shall also provide the raw materials, utilities, lubricants, chemicals, catalysts, Works, services and other

matters required for testing and commissioning. The Contractor must provide all operating staff prior to Taking Over for testing and commissioning.

7.7 Ownership of Plant and Materials

The Contractor warrants that the Plant and Materials are or will at the point that ownership transfers to the Employer pursuant to this Sub Clause 7.7 and until the date of issue of the Taking-Over Certificate, be free of any lien, pledge, mortgage, charge, or encumbrance whatsoever (save in respect of any rights acquired by the Employer) and in the case of any Security Interest existing over any of the Plant or Materials (or part thereof), the Contractor shall register or procure the registration of a financing change statement wholly releasing each such Security Interest prior to transfer of ownership to the Employer pursuant to this Sub Clause 7.7.

8 Commencement, Delays and Suspension

8.1 Commencement of Work

First paragraph, second sentence, delete "Particular Conditions" *and substitute:* "Preamble".

8.3 Programme

Delete the first two sentences of the first paragraph and substitute:

"The Contractor shall prepare a revised programme when required to do so by the Specification, or when instructed to do so by the Engineer. The period within which the Contractor shall submit a revised programme for approval, either having been asked to do so by the Engineer or following disapproval of a previous submission, is 7 days. Each revised programme shall show the effect of Variations, extensions of Time for Completion granted and how any delays are to be dealt with. The form of the programme shall be as set out in the Specification."

Add the following after (d)(ii):

"(e) Any other requirements set out or required by the Specification."

9 Tests on Completion

9.4 Failure to Pass Tests on Completion

Add to the end of Sub Clause 9.4 (a):

"The Contractor shall at no cost to the Employer rectify, modify or replace the Plant and repeat the Tests as often as may be determined by the Engineer acting reasonably until the said Tests have been passed."

Add the following to Sub-Clause 9.4

If the Contractor does not attend the Tests on Completion, the tests shall be deemed to have been conducted with the consent of the Contractor and the results of the tests shall be accepted as accurate.

9.5 Tests after Completion

Add new sub-clause

Should the Engineer approve Tests on Completion or Functional Guarantee Tests taking place after Taking Over, the requirements of Clause 12 as modified by the Particular Conditions shall apply.

10.3 Interference with Tests On Completion

Add new paragraph to before the final paragraph of this Clause

Nothing in this clause shall prevent the Engineer from instructed that the Tests on Completion be carried out as Tests after Completion

11 Defects Liability

11.9 Performance Certificate

Delete the second paragraph and substitute:

"The Engineer shall issue the Performance Certificate within 28 days after the latest of the expiry dates of the Defects Notification Periods, or as soon as practicable thereafter, provided that the Contractor has supplied all the Contractor's Documents, completed and tested all the Works, including remedying any defects, and received an Acceptance Certificate pursuant to Sub Clause 12.5. For the avoidance of doubt, the Engineer shall not be obliged to issue the Performance Certificate until all of the above conditions have been satisfied."

Add the following at the end of the Sub Clause:

"The issue of the Performance Certificate shall not relieve the Contractor from any liability in respect of:

(a) fraud or dishonesty relating to the Works or any part thereof or to any matter dealt with in the Performance Certificate;

(b) any incidental or erroneous inclusion or exclusion in the Performance Certificate;

(c) any unresolved issues the subject of a notice of dispute pursuant to Sub Clause 20.2, served before the seventh day after the issue of the Performance Certificate

(d) any other deed or agreement entered into between the Employer and the Contractor (whether or not with any other parties) relating to all or any part of the Works."

11A Supplier Warranties

Add a new Clause:

"The Contractor shall obtain from any supplier of Plant for the Works warranties for defective product and workmanship ("the Supplier Warranties") on the relevant suppliers' usual commercial terms and for a period agreed upon between the Employer and the Contractor (acting reasonably) which period shall in any event not be less than, nor expire prior to expiry of, the Defects Notification Period. To the extent permissible the Supplier Warranties shall be assigned by the Contractor to the Employer to the intent that the Employer shall be entitled to the full benefit of such warranty. To the extent that the Supplier Warranties are not assignable, they shall be held on trust by the Contractor for and on behalf of the Employer to the intent that as between the Employer and the Contractor, the Employer shall be entitled to

the full benefit of the Supplier Warranties. The Supplier Warranties shall not limit the obligations placed on the Contractor under this Contract. The Contractor shall take all necessary and reasonable steps to assist the Employer in the enforcement of any Supplier Warranties.

12 Tests After Completion

12.1 Procedure for Tests after Completion

Delete the first sentence of Sub Clause 12.1 and replace with the following:

*"*If Tests after Completion are specified in the Contract, or if the Engineer agrees to Tests on Completion being delayed until after Taking Over in accordance with Clause 9.5 of the Particular Conditions, this Clause shall apply*:"*

12.5 Acceptance Certificate

Add the following new Sub Clause to Clause 12:

"The Engineer will issue an Acceptance Certificate when the Works have met all requirements for Taking Over, and the Recommissioning Tests detailed in Part 8.12 for each Section have been completed either as part of the Tests on Completion or have been completed after Taking Over as Tests After Completion and fully meet all of the obligations under this Contract. The issue of an Acceptance Certificate does not affect the Defects Notification Period.

The Contractor may apply by notice to the Engineer for an Acceptance Certificate in respect of the Works or, if the Works are divided into Sections, in respect of each Section, at any time after completion of the Tests after Completion.

The Engineer shall, within 28 days after receiving the Contractor's application:

(a) issue the Acceptance Certificate to the Contractor, stating the date on which the Works or Section were completed in accordance with the Contract, except for any minor outstanding work and/or defects which will not affect the use of the Works or Section for their intended purpose (either until or whilst this work is completed and/or these defects are remedied); or

(b) reject the application, giving reasons and specifying the work required to be done by the Contractor to enable the Acceptance Certificate to be issued. The Contractor shall then complete this work before issuing a further notice under this Sub Clause."

13 Variations and Adjustments

Variation Procedure **New** Sub Clause 13..3.1

Unforeseen Work

Where work not specified in the contractor is identified during the pre-disassembly testing or after disassembly the following procedure shall apply:

a) The Contractor shall bring the matter to the notice of the Engineer as soon as possible or in the reports prepared at pre dis-assembly and post dis-assembly phase at the

latest.

b) If the Contractor believes any additional work is essential then they should commence preparing a formal price prior to receiving a formal Variation Price Request;
c) The Engineer will issue a price Variation Request as soon as possible;
d) The Contractor will be required to attend to these promptly and within 3 days at most to avoid any delay to the project.
e) The Contractor should assume that a firm price will be required before the Engineer can confirm any item of additional work not set out in the Contract. The Engineer will issue the Variation, if it is accepted, within 2 days.
f) The failure to provide firm pricing in the required time scale will not provide a reason for a time extension to the Section of Work.
g) The Employer is most unlikely to allow additional work to proceed without a formal price for the agreed scope.

13.5 Provisional Sums

Delete the second sentence in (b)(ii)

13.8 Adjustments for Changes in Cost

Delete the Sub Clause and insert:

As stated in the Preamble the Contractor shall be permitted to adjust the price as the works proceed using the index method that is agreed at the commencement of the Contract, as detailed in the Letter of Acceptance.

(Add new paragraph to end of sub-clause)

Where a variation is granted the price shall be valid from the date the Engineer approved the Variation rather than from the Base Date.

14 Contract Price and Payment

14.1 The Contract Price

(Add the following to sub-paragraph (e) as follows)

However, the Contractor shall be responsible for the payment of any redeemable bond posted by the relevant authorities in the Country in relation to the importation of the Contractor's Equipment.

14.5 Plant and Materials Intended for the Works

Delete the Sub Clause and insert:

"Progress payments during manufacture of the Plant and Materials off Site in Fiji will be made subject to:

(a) The Contractor certifying to the Employer the items of Plant covered by the payment are at a location within The Fiji Islands and that the ownership of completed or identified items of Plant and Materials has passed to the Employer.

(b) The Contractor marking the certified Plant and Materials as being the property of the Employer and separately storing such Plant and Materials.

(c) The certified Plant and Materials being made available for inspection by the Engineer or by an inspector appointed by

the Engineer.

Progress payments during manufacture of the Plant and Materials off Site outside Fiji will be allowed subject to the Contractor certifying to the Employer that the ownership of completed or identified items of Plant and Materials has passed to the Employer and the Contractor has provided the Employer with an unconditional bank guarantee to the value of the progress payment claimed.

No progress payments for off-Site manufacture of Plant and Materials will be made by the Employer unless all of the above conditions have been met.

14.6 Issue of Interim Payment Certificates

Replace the first paragraph of this Sub Clause with the following;

"No amount will be certified or paid until the Engineer has received and approved the Performance Security and the certificates of insurance required from the Contractor in accordance with Clause 18 [Insurance]. Thereafter, the Engineer shall after receiving a Statement and supporting documents, issue to the Employer an Interim Payment Certificate which shall state the amount which the Engineer fairly determines to be due, with supporting particulars."

14.7 Payment

Add the following Sub Clause

14.7.1 Interim Payment Procedure

The procedures and timing for interim progress payments shall be as follows:

(a) Each Statement shall be in writing and comply with the requirements of the Contract.

(b) The Contractor shall submit each Statement to the Engineer by the seventh day of the month following the month in respect of which the Statement is calculated.

(c) Within seven days of receipt of each Statement the Engineer shall issue a Payment Certificate in respect of the Statement and provide a copy to the Contractor.

(d) Each Payment Certificate shall identify the Payment Claim to which it responds, indicate the amount that the Engineer fairly determines to be due and show the manner in which the amount due has been calculated.

(e) If the amount indicated on a Payment Certificate differs from the amount claimed in a Statement, the Payment Certificate will provide reasons for the difference.

(f) The Contractor shall submit a tax invoice to the Employer for the amount to be paid as shown on a Payment Certificate within five days of receipt of the Payment Certificate.

(g) Subject to compliance by the Contractor with the provisions of this Sub Clause, the Employer will pay the invoiced amount within 56 days following receipt of the Contractor's tax invoice.

(h) For the purposes of interpreting the requirements of the

Contract:

(a) The Employer acknowledges that all Payment Certificates issued by the Engineer shall be regarded as payment schedules and that the Engineer has the full authority and support of the Employer in issuing such payment schedules or certificates in the Employer's name; and

(b) The Contractor acknowledges that the Engineer has the full authority and support of the Employer in issuing the payment schedules or certificates and the Contractor acknowledges that the Employer can only make payment against correct tax invoices prepared by the Contractor for the amount specified in the payment schedules or certificates."

14 Delayed Payment

Delete the second paragraph and substitute:

"Financing charges shall be calculated using the annual interest rate as set out in the Preamble."

14.11 Application for Final Payment certificate

Delete the last sentence and substitute:

"Thereafter, if the dispute is finally resolved under Clause 20, the Contractor shall then prepare and submit to the Employer (with a copy to the Engineer) a Final Statement.

14.13 Issue of Final Payment Certificate

Add at the end of the Sub Clause:

"The Contractor shall submit a tax invoice to the Employer for the amount to be paid as shown on the Final Payment Certificate within five days of receipt of the Payment Certificate.

Subject to compliance by the Contractor with the provisions of this Sub Clause, the Employer will pay the invoiced amount within 56 days following receipt of the Contractor's tax invoice."

14.15 Currencies of Payment

Add at the end of the Sub Clause:

"No adjustment of the Contract Price shall be made for any fluctuations in the rate of exchange between the currency of the Contractor's country of origin and any other currency."

14.16 Fiji Islands Taxation

Add new sub-clause 14.16 to Clause 14

14.16.1 Withholding Tax

(Add a new sub-clause 14.16.1 stating :)

The Contractor must include 15% as withholding tax in their invoices for the labour component of on-shore costs.

14.6.2 Company Tax

(Add a new sub-clause 14.16.2 stating:)

The Contractor is responsible for paying all income tax due on profits earned in Fiji. The Employer will not compensate the Contractor for this taxation.

14.6.3 Personal Tax

(Add a new sub-clause 14.16.3 stating:)

The staff of the Contractor are responsible for paying all income tax due on income earned in Fiji. The Employer will not compensate the Contractor, or its staff, for this taxation, regardless of whether the staff are Fijian nationals or residents of

another country.

14.6.4 Import Duties

(Add a new sub-clause 14.16.4 stating:)

14.6.4.1 The Contractor shall, at least 14 days before scheduled arrival of all or any part of the Plant and Materials at a Port in Fiji, provide the Employer with:

(a) original and 2 copies of the packing list including weight and description;

(b) full set of original Bill of Lading marked “shipped on board”; and

(c) Certificate of country of origin,

For the Plant and Materials being shipped.

14.6.4.2. The Employer is only responsible to clear from the Port in Fiji, all Plant and Materials imported to form part of the Permanent Works and shall pay import duty and import VAT on the said Plant and Materials.

14.6.4.3. The Contractor is responsible for clearing all Contractor’s Equipment imported for temporary purposes and not intended to form part of the Permanent Works and shall establish any necessary bonds, pay any applicable import duty and import VAT on the said Contractor’s Equipment and Plant and Materials.

14.6.4.4 Notwithstanding sub-clauses 14.6.4.2 and 14.6.4.3 above, the Contractor shall ensure that all customs and import duties and taxes are paid on time (including making payment for duties and taxes which are the responsibility of the Employer and invoicing the Employer therefor after the fact). For the avoidance of doubt the Contractor shall not be entitled to any extension of time as a result of any delayed payments of import duties and taxes which was within its control

In amplification of the above, import duties for renewable energy projects have been zero-rated by the Fijian Government. The Contractor shall be responsible for determining the requirements for securing exemption from import duties.

The Contractor shall provide the Employer, or other authority indicated by the Employer, with all documentation necessary to secure exemption of shipments of Goods from import duties and to expedite clearance through Fiji Customs. The Contractor shall submit all necessary documentation in sufficient time that release of shipments from Customs will meet the requirements of the construction programme, and the necessary documentation shall be submitted not less than three (3) weeks prior to the arrival in Fiji of any shipment.

As a minimum and without limiting the Contractor’s responsibility to ascertain the requirements for exemption from import duties, all shipments of Goods must be clearly labelled: “Equipment Supply for the Wailoa Generator Rehabilitation Contract”.

The Contractor shall comply with any reasonable request or recommendation of the Engineer or Employer in respect of importation formalities, including but not limited to the appointment of an acceptable local agent to assist with importation formalities.

Notwithstanding the other provisions of this Sub-Clause, the Contractor shall be responsible for the payment of customs, import duties and taxes levied in consequence of the importation of Goods. Loss of duty free status for any shipment or shipments, delays or additional costs incurred by the Contractor as a result of the Contractor's failure to abide by the requirements of the Contract or as a result of any act or omission of the Contractor contrary to the advice or legitimate requests of the Employer, relevant Fiji authorities or the Engineer, shall not be reimbursable to the Contractor nor constitute grounds for an extension of Time for Completion.

If the Contractor ascertains that import duties will be levied because an imported item is not subject to exemption under the zero-rating for renewable energy projects, the Contractor shall inform the Engineer forthwith and demonstrate that equivalent quality Goods could not be procured from within Fiji at a lower overall cost to the Employer. If the Engineer considers that the item is indeed not subject to exemption and that equivalent quality Goods could not be procured from within Fiji at a lower overall cost to the Employer, the additional cost to the Contractor of the levied import duties shall be assessed by the Engineer and added to the Contract Price.

14.17 Direct Payment

(Add new Sub-Clause 14.17 as follows)

Before issue of the Final Payment Certificate, the Employer may pay unpaid moneys owed by the Contractor to a worker or a subcontractor directly to that worker or subcontractor, where:

a) permitted by law;

b) given a court order in favour of the worker or subcontractor; or

c) Requested in writing by the Contractor.

Such payment made to a worker or subcontractor in compliance with a legislative requirement shall be deemed to be part-satisfaction of the Employer's obligation to pay pursuant to Sub-Clause 14.7 [Payment].

15 Termination by Employer

15.2 Termination by Employer

Add the following sub-paragraph (g):

"(g) commits any other material breach of the Contract which is not remedied within 14 days of receiving notice of the breach from the Employer,"

Add the following at the end of the last paragraph of Sub Clause 15.2:

"Without limiting the foregoing provisions, upon termination of the Contractor's employment under the Contract, the following shall apply:

(a) the Contractor shall, when and if required by the Employer, assign to the Employer all of its rights under all or any of the subcontracts;

(b) the Contractor shall co-operate with the Engineer in the

transfer of information and disposition of work in progress so as to mitigate the cost to the Employer of the termination of the Contractor's employment;

(c) the Contractor shall comply with all other reasonable requests from the Engineer and co-operate with and provide all reasonable assistance to the successor contractor (if any) and/or the Employer following the termination of the Contractor's employment to ensure that there is a smooth and efficient handover of the Works to any successor contractor and/or the Employer as the case may be;

(d) if requested to do so by the Employer, the Contractor shall assign to the Employer any or all of the Contractor's rights under the Contractor's shipping documentation (if any) for items of Plant and/or Materials to be supplied for incorporation into the Works and execute all documentation and do all things reasonably required by the Employer to effect such assignment, within 14 days of being requested to do the same;

(e) the Employer may pay any Subcontractor for any Materials or Goods delivered or works executed for the purpose of the Contract (whether before or after date of termination) insofar as the price thereof has not already been paid by the Contractor. Payments made under this Sub Clause may be deducted from any sums due or to become due to the Contractor. It is a condition of this contract that the Contractor is entitled to be paid any such sum as, in the event of termination and the making of any direct payments pursuant to this Clause 15 [Termination by Employer], may remain after the amount equivalent to such direct payment has, in addition to any other amounts certified by the Engineer under this Sub Clause, been debited against the Contactor;

(f) the Contractor shall provide to the Employer upon request and as a precondition to receiving any payment under this Clause 15 [Termination by Employer], such evidence as the Employer shall reasonably require to satisfy the Employer that property in all Plant and Materials which have been supplied by the Contractor to the Employer has vested (or will upon such payment vest) in the Employer."

17 Risk and Responsibility

17.4 Consequences of Employer's Risks

*First paragraph, delete the word "*Goods*" in the second line.*

17.6 Limitation of Liability

Add the words:

"Sub Clause 8.7 *[Delay Damages]*" *after the word* "under" *on line 3*.

18 Insurance

18.1 General Requirements for

Fourth paragraph; replace the first sentence with the following:

"Where the Contract requires insurance to be effected in joint

	Insurances	names: 1. The cover shall apply separately to each insured as though a separate policy had been issued for each of the joint insured. 2. The policy or policies shall provide for waiver of subrogation with respect to each of the insured." *Sixth paragraph; replace* "the respective periods stated in the Appendix to Tender" *with* "14 days".
18.2	**Insurance for Works and Contractor's Equipment**	The Employer shall be the insurer for project works on site. The Contractor is responsible for the insurance of the Project Works while in their possession and in transit to and from the site. *Fourth paragraph, sub-paragraph (d), replace* "the amount stated in the Appendix to Tender" *with* "$AUD50,000.00 or as may otherwise be agreed by the Employer".
18.3	**Insurance against Injury to Persons and Damage to Property**	*Second paragraph, replace* "Appendix to Tender" *with "*Preamble". *Third paragraph, delete sub-paragraph (d)(i)*
18.5	**Professional Indemnity Insurance**	*Add the following new Sub Clauses to Clause 18:* "The Contractor shall effect and maintain professional indemnity insurance, which shall cover the risk of professional negligence in the design of the Works, for an amount not less than that specified in the Preamble for any one claim or series of claims arising out of the same occurrence.
18.6	**Motor Vehicle Third Party Liability Insurance**	"The Contractor shall effect and maintain, until expiry of the Defects Notification Period, motor vehicle third party liability insurance for an amount not less than that specified in the Preamble for any of the Contractor's vehicles used and operated in Fiji."
20	**Claims, Disputes and Arbitration**	
		Delete Sub Clauses 20.2 to 20.8 inclusive and substitute the following Sub Clauses:
20.2	**Disputes**	"If either party is dissatisfied with a decision or instruction of the Engineer, or if no decision is given by the Engineer within a prescribed time frame under this Contract or there is some other dispute between the Contractor and the Employer in relation to this Contract, then the dissatisfied party may refer the matter to mediation or arbitration pursuant to Sub Clauses 20.3 or 20.4 respectively. Unless the dissatisfied party has notified the other party and the Engineer within 28 days of such decision or instruction of its intention to refer the matter to mediation or arbitration it shall be deemed to have accepted the decision or instruction as final."
20.3	**Mediation**	"Where a request for mediation is made the parties shall endeavour to agree on a mediator and shall submit the dispute to

him/her. The mediator shall discuss the matter with the parties and seek to resolve the dispute by agreement. All discussions in mediation shall be without prejudice and shall not be referred to in any later proceedings. The parties shall bear their own costs in the mediation and shall each pay half the costs of the mediator.

The parties may at any stage agree to invite the mediator to give a decision to determine the matter. The mediator's decision shall in such case be binding on both parties unless within 14 days either party notifies the other in writing that it rejects the mediator's determination.

If:

(a) Mediation has been requested but has not been agreed upon within 14 days of the request, or

(b) Within 14 days of mediation being requested the parties have been unable to agree upon a mediator, or

(c) No agreement has been reached in mediation and no determination has been issued by the mediator within 56 days of the request for mediation, or

(d) either party has, within the prescribed time rejected the mediator's determination,

then the matter may be referred to arbitration."

20.4 Arbitration

"A notice requiring arbitration shall be in writing and shall be given by the dissatisfied party in accordance with the time frame in Sub Clause 20.2 [*Disputes*] or within 28 days after the happening of the event in Sub Clause 20.3 [*Mediation*] which gives rise to the arbitration.

Arbitration shall be in accordance with the Rules of Arbitration of the International Chamber of Commerce (ICC). The law governing the procedure and administration of any arbitration is Republic of the Fiji Islands law. The place of arbitration shall be Suva, The Fiji Islands

The arbitrator shall have full power to open up, review and revise any decision, opinion, instruction, direction certificate or valuation of the Engineer and to award on all questions referred to him/her. Neither party to the arbitration shall be limited to the evidence or arguments put before the Engineer or put before a mediator.

No decision given by the Engineer in accordance with his/her duties under the Contract shall disentitle him/her from being called as a witness and giving evidence before any hearing on any matter relevant to the dispute.

Where the matter has been referred to mediation the mediator shall not be called by either party as a witness, and no reference shall be made to the determination, if any, issued by the mediator in respect of the matter in dispute."

20.5 Works to Continue

"Performance of the Contract shall continue during mediation or arbitration proceedings unless the Employer shall order suspension. If any such suspension is ordered the documented costs incurred by the Contractor and occasioned thereby shall be added to the Contract Price.

No payments due or payable by the Employer shall be withheld on account of pending reference to mediation or arbitration."

Appendix and Annex *delete*

5 Specification – Preliminary and General

5.1 General

5.1.1 Location

The Site of the proposed Works is the Wailoa powerstation on Viti Levu in the Republic of the Fiji Islands. The site is normally accessed by road from the Capital, Suva.

Figure 1 – Viti Levu Island, Fiji. Approximate site location shown in red box

5.1.2 Access

Only construction vehicles will be allowed in the construction zone. All other vehicles shall be parked in the designated contractor staff car parking areas.

5.1.3 Site

The Contractor and his/her staff shall comply with the Employer's requirements for external contractors when working on the Site.

5.1.4 Construction Activities to be provided by the Employer

The Employer will provide the following services and construction work as part of this project;

a) Provide accommodation, free of charge for the Contractor's team at Wailoa Camp which is approximately one kilometre from the power station. The contractor will need to arrange their own food but the Employer can assist in arranging a cook and cleaner to be available;
b) The Contractor must provide its own accommodation at other locations in Fiji;
c) Crane and operator at site to assist with plant installation;
d) The Contractor is required to co-operate with the Employer in all respects in the provision of these services.

5.2 Payments

Payment will be made on completion of milestones as set out below:-

Milestone	Milestone Payment Basis	Maximum Milestone Payment
The following applies to each of Sections 1 to 4		
Advance Payment (Sections 1, 2, 3 and 4 only)	Lump Sum	10% of Contract Section Price. Paid within 14 days of the Commencement Date for each Section
Basic Design Report (Section 1 only)	Lump Sum	5% of Contract Section Price
Detailed Design Report (Section 1 only)	Lump Sum	5% of Contract Section Price
Manufacture and delivery of parts for shipment to Fiji.	Based on monthly claims for the percentage of completion of equipment under manufacture at the Contractor's and/or Subcontractor's workshop. Payments for components delivered from suppliers shall be due on delivery to site or the Contractors store. All progress payments for offsite work shall be subject to the claim procedure described in Section 4.2, clause 14.5 for details of the claim procedure.	Total payments for the Section up to 30% of the Section Contract Price less 25% retentions on the total approved payments due for the Section of Work
Site work during outage	Based on monthly claims for the percentage of completion of refurbishment work on site.	Total payments for the Section up to 85% of the Section Contract Price less 25% retentions on the total approved payments due for the Section of Work
On Approval of Preliminary Manuals	Lump sum	1.5% of Contract Section Price
Completion of Installation and Commissioning	Up to 90% of the contract price.	Total payment up to 90% of Section Contract Price less 10% retentions on the total approved payments due

On Taking Over	95% of the contract price.	Total payment up to 95% of Section Contract Price less 0% retentions on the total approved payments due
On Approval of the Final Manuals, Test Reports and As Built Drawings	Lump sum	1.5% of Contract Section Price
On granting Acceptance Certificate	Balance of monies due for the Section.	Balance of monies due for the Section
Defects Notification Period	Covered by a 5% Performance Bond for each Section – no retentions. 5% retentions will be held until the revised Performance Bond is received	

The Contractor shall submit a schedule of payments within one month of tender acceptance for agreement by the Engineer. This schedule is to be used by the Employer for financial planning only and not for payment to the Contractor.

Delivery shall mean delivery to the project site or other store in The Fiji Islands as may be approved by the Engineer. For overseas sourced items manufactured specifically for this contract, payment will be made on presentation of certified shipping documents.

5.3 Programme

The following programme shall apply for the refurbishment of each of Sections 1 to 4 of the Contract. Please note one week equals seven days as defined in the General Conditions of Contract. All durations for each Section are cumulative starting on the Commencement Date of that Section.

Activity	Section 1 Duration	Section 2 Duration	Section 3 Duration	Section 4 Duration
Basic Design Report (first generator only)	4 weeks			
Approval of Basic Design Report	14 days			
Preparation of detailed design report and detailed construction drawings (first generator only)	8 weeks			
Approval of detailed design report and construction drawings	14 days			
Manufacture items required for rehabilitation	16 weeks	16 weeks	16 weeks	16 weeks
Transport items required for rehabilitation to site	6 weeks	6 weeks	6 weeks	6 weeks
Outage period for rehabilitation	90 days	90 days	90 days	90 days

Activity	Section 1 Duration	Section 2 Duration	Section 3 Duration	Section 4 Duration
Commissioning and Tests on Completion	14 days	14 days	14 days	14 days
Trail Operation	720 hours	720 hours	720 hours	720 hours
Taking Over Certificate	0 days	0 days	0 days	0 days
Defects Liability Period	12 months	12 months	12 months	12 months
Acceptance Certificate	0 days	0 days	0 days	0 days
Total Duration (Days)	**417**	**261**	**372**	**274**
Preliminary Site Installation Dates				
Outage Commence	11 July 2017	30 March 2018	19 July 2018	19 April 2019
Tests on Completion Completed and Unit returned to service (Taking Over)	23 October 2017	12 July 2018	31 October 2018	1 August 2019
Trial Operation Complete (Acceptance)	22 November 2017	11 August 2018	30 November 2018	31 August 2019
Defects Notification Period Ends	17 November 2018	6 August 2019	25 November 2019	25 August 2020

All installation work shall be completed in accordance with a detailed installation schedule that has been submitted to and meets with the Engineer's approval prior to the start of installation work.

As numerous other upgrade works will be taking place concurrently on the turbine generator unit there will be no opportunity to commission each Section earlier than the scheduled dates. The generator rehabilitation site works for each Section shall commence on the scheduled outage date so as to minimise the risk of time overruns.

A detailed schedule must be provided 4 weeks after the Contract Acceptance date and revised 4 weeks prior to commencing any work on site.

5.4 Training

As part of this contract the Contractor shall include comprehensive training of the staff to levels suitable for accreditation to ISO 9001/2.

Included in the training shall be:-

- Description of the entire plant;
- Operation of the plant (hands on) in all modes;
- Identification and function of all plant components;
- Performance assessment;
- Routine maintenance and annual servicing procedures and requirements;
- Identification of faults and trouble-shooting;
- Reporting;

- Safety; and
- Use of the Manuals.

The Contractor shall be required to demonstrate to the Engineers satisfaction that he has adequately trained the nominated staff members so they have been well trained and are fully conversant with all aspects of operation, maintenance and procedures associated with the Plant.

The Acceptance Certificate will not be issued until all training requirements have been satisfied.

5.5 Tests on Completion

5.5.1 Tests on Completion

The Tests on Completion for each Section are detailed in Part 8.12 of the Specification.

5.5.2 Tests after Completion

It is expected that all Tests on Completion of the each generator will be completed before Taking Over is granted. However, the Employer may require some or all of the Tests on Completion to be carried out as Tests after Completion owing to station operating requirements.

5.5.3 Acceptance Certificate

When the above tests on are completed the Engineer will issue an Acceptance Certificate confirming the tests have been carried out and the test criteria has been met..

5.5.4 Performance Shortfall during Defects Notification Period

Should any performance shortfall be identified during the Defects Notification Period, the Contractor shall be responsible for taking immediate steps to determine and effectively correct the fault. The performance test shall be repeated by the Contractor after any resulting plant modifications.

5.6 Site Services

5.6.1 Electricity

A 400 VAC, 4 wire plus earth, 3 phase 50 Hz and a 230 VAC, two wire plus earth, single phase 50 Hz power supply adequate for the Contractor's nominated requirements will be made available. Supply will be available by arrangement at all hours but liability will not be accepted by the Employer for any loss, damage or inconvenience created resulting from the total or partial interruption of the supply.

5.6.2 Water Supply

A potable water supply is not available at the Site for construction use. The Contractor will be required to make his own arrangements for the provision of bottled water and beverages for staff. .

5.6.3 Fire Protection

The Contractor shall provide fire extinguishers of an appropriate capacity and type at all locations where work is carried out.

5.7 Health and Safety

5.7.1 Health and Safety Procedures

The Contractor's and Sub-contractor's employees on Site shall adhere to the safety procedures established for the Site including: any lawful instruction given to them by an authorised person; emergency and evacuation procedures; the use of fire-fighting appliances; the observance of all industrial regulations relating to the Works; the observance of the shutdown of plant procedures and compliance with Site plant isolation procedures.

All Contractor employees including any Sub-contractor's employed on Site shall attend Site Induction Courses as required prior to the start of work on Site. All work on site shall be subject to and comply with the Site Health and Safety Policy, which is available to the Contractor upon request.

5.7.2 Health and Safety Regulations

The Contractor is required to ensure that the requirements of The Fiji Health and Safety at Work Act 1996 along with the Health and Safety in Employment Regulations and various Codes of Practice are observed by its own employees and those of his Sub-contractors and shall submit, prior to commencing the Works, a Site record sheet to the Engineer that confirms that all employee have been given the current information covering health and safety. The Contractor shall submit an updated Site record sheet weekly.

5.7.3 Accidents

The Contractor shall promptly report within 24 hours in writing to the Engineer all accidents and incidents that caused injury, illness and those that might have caused injury. In addition, if death, serious injury, or serious damages are caused, the accident shall be reported immediately by telephone or messenger to the Engineer and The Occupational Safety and Health Department. If any claim is made by anyone against the Contractor as a result of any accident, the Contractor shall promptly give a complete report of the facts in writing to the Engineer giving full details of the claim, including witnesses, statements, sketches and the like.

5.7.4 Barricades

Barricades, fences or guard-rails must be provided around all excavations or openings where there is a risk of persons falling into them. Such barricades shall be erected after the completion of the day's work and/or when the Site is left unattended and shall be brightly coloured and clearly visible at night. Such barricades shall not be removed without written permission by the Contractor's Safety Supervisor.

5.7.5 Safety Supervisors

The Contractor's Safety Supervisor nominated for the Site shall have their name displayed on all facilities and the person's name is to be known by all employees and in accordance with The Fiji Health

and Safety at Work Act 1996. The Contractors Safety Supervisor shall be responsible for all safety matters and shall liaise with the Engineer.

5.7.6 Security Fencing

The Contractor is not required to provide security fencing around the perimeter of or within the Site. However, the Contractor shall be responsible for the provision of all temporary fences, barriers and signage as appropriate to effectively isolate hazards associated with the works.

5.7.7 Protective Helmets and High Visibility Jackets

The Employer will designate protective helmet areas. All Contractors' employees, sub-contractors employees, visitors and delivery personnel shall wear a hard hat at all times within such designated areas. Contractors must advise all appropriate people. Hard hats are to be replaced every three (3) years and are not to be painted. Only the company logo may be attached.

High visibility jackets shall be worn at all times and in all areas designated by the Employer.

5.7.8 Lighting

The Contractor shall provide artificial lighting when natural lighting becomes inadequate at any walking access-way and construction space. The artificial lighting may be by either the permanent lighting installation or by a temporary installation which is later removed once the permanent installation is complete.

5.7.9 Radios

No broadcast frequency radios, Walkman's, radio cassettes CD players, MP3 players, or other similar devices shall be permitted on the construction work areas.

5.7.10 Safety Signs

The Contractor's employees shall observe and comply with all safety signs displayed about the Site. These signs inform personnel both of safety equipment that is required and the hazards that personnel may encounter in special areas.

5.7.11 Alcohol & Illegal Drugs and Substances

Illegal drugs and substances are not permitted on Site. Alcohol must not be brought on Site or be consumed on Site unless approved by the Site Manager. Personnel reporting for duty or seen on Site under the influence of drugs, substances or alcohol will not be allowed to commence work and will be asked to leave the Site.

5.7.12 Animals

Animals are not permitted on Site.

5.7.13 Children

Children under the age of 15 are not permitted on Site.

5.7.14 Contractor's Responsibilities for Health and Safety

The Employer requires the Contractor to comply with safety regulations detailed herein. Compliance with these safety regulations shall not relieve the Contractor of his obligations under the Contract, The Fiji Health and Safety at Work Act 1996, and any amendments thereto.

The Contractor shall:

- Ensure that Contractor and Sub-contractor employees have the necessary skills, qualifications and are supervised by trained personnel to perform the contracted Works safely;
- Audit the performance of Contractor and Sub-contractor employees to ensure compliance to Health and Safety at Work Act 1996 and Site requirements and report each month in the prescribed form to the Engineer. In addition, the Contractor shall report weekly to the Engineer as to the total number of personnel (including Sub-contractors) employed on Site over the last week;
- Inform the Engineer of Health and Safety hazards presented by the Contractor's or Sub-contractor's Works;
- Inform the Engineer of Health and Safety hazards found by Contractor or Sub-contractor whilst undertaking Works;
- Ensure that Health and Safety equipment and clothing is supplied to protect Contractor and sub-contractor employees from the hazards their work creates and that all steps have been taken to prevent harm to other people in the area from the hazard created; and
- The Contractor has the responsibility for informing each Sub-contractor of Health and Safety hazards they may be exposed to and the controls in place to protect them including hazards that may be created by other contractors.
- The Contractor shall run minuted toolbox meetings involving all staff working on site.

5.7.15 Fire Regulations

The Contractor shall provide and maintain adequate fire prevention equipment facilities in areas of potential fire hazard, including, but not limited to, portable fire extinguishers, fire protection mats and fire watchers. In the event of any fire, the Contractor shall take all steps necessary to extinguish the fire and contain its effects and shall report promptly in writing to the Engineer the cause and extent of damage resulting there from.

5.7.16 Housekeeping

The Contractor is responsible for keeping all work areas free from accumulated rubbish at all times and shall deposit rubbish in the central rubbish skips.

5.7.17 Asbestos

The Contractor shall, as part of refurbishment services, assess and test relevant parts of each generator rotor assembly for the presence of asbestos materials. Asbestos may be present in the assemblies of older generators, including (but not limited to) end winding blocking and insulation materials. Suspected asbestos or asbestos-containing materials shall be assessed, their condition determined by inspection, and samples shall be removed and placed in double snap-lock plastic bags. The samples shall be submitted to a certified asbestos testing laboratory for confirmation of the presence / absence of

asbestos and, if present, the type of asbestos. The method for obtaining samples of suspected asbestos-containing materials shall follow that set out in “Asbestos - New Zealand guidelines for the management and removal of asbestos (3rd Edition)” (available for download on the Worksafe New Zealand website), or an equivalent method

5.7.18 Responsibility - Employer

The Employer will:

- Document procedures for Contractor and Sub-contractor personnel movements in and out of the Site or nominated work areas;
- Advise the designated Site Health and Safety Officer;
- Facilitate regular Health and Safety meetings with Contractor's Occupational Health and Safety representatives; and
- Undertake Health and Safety Audits.

5.8 Contractor's Administration

5.8.1 Contractor's Supervisor

The Contractor shall appoint a properly qualified and experienced supervisor to control and direct his staff at Site and the appointed supervisor or replacement approved by the Engineer shall be on Site whenever members of the Contractor's staff are working. The supervisor shall not be replaced except by agreement with the Engineer.

The Contractor's supervisor shall be entirely responsible for the direction of employees of the Contractor and shall be given authority to negotiate and agree points arising out of the erection in order to minimise delays. All instructions from the Engineer will be issued to the appointed supervisor.

5.8.2 Meetings

Meetings will be convened by the Engineer at regular intervals which will not be less frequent than monthly and may be weekly at critical periods. The Contractor shall ensure that a senior person conversant with the project and with decision making authority attends each meeting.

5.9 Co-operation

The Contractor shall co-operate with Site staff, and other contractors on the Site as applicable, to ensure an orderly programme.

5.10 Site Operations

5.10.1 General

At all times the Contractor and his work force shall observe the Employer’s requirements in regard to safety and power scheme operating conditions and shall carry out no acts which would, or have the potential to, cause damage or down-time of any Site operations.

5.10.2 Site Specific Entry Conditions

The Contractor is required to ensure that he and all employees and sub-contractors comply with all Site specific entry conditions as may be issued by the Employer from time to time.

5.11 Delivery Procedures

In the event of plant or sections thereof being supplied from outside The Fiji Islands, such plant shall be delivered to a port in the country of manufacture for direct shipment to the specified port in Fiji. Plant must not be shipped on deck unless in containers.

The Contractor shall:

- Arrange for a mutually approved authority to inspect the manufacture, witness testing of the plant and certify that materials, tests and specifications meet the Employer's requirements and comply with the requirements of those codes specified by the Employer;
- Arrange an independent survey certificate verifying that the packing is adequate and sufficient for the required land, ocean and/or air transit to the final destination determined by the Employer certifying in particular that the packing complies with Fiji Government Regulations;
- the wooden packing cases or timber used in packing machinery for shipment are free of bark and/or obvious insect damage, are certified and cleared by the overseas shippers and that all packing is clean and new;
- Supply to the Employer copies of both of these certificates with the shipping documents; and
- Indemnify the Employer against all liabilities, claims, costs and expenses that may result from failure of the Contractor to comply with the above mentioned conditions;

All wooden packing cases or timber used in packing machinery from overseas shall be fumigated prior to delivery to Site and following equipment unpacking it shall be delivered to a nominated Site area for incineration. This material shall not be used on Site for construction activities.

5.12 Manuals and As-Built Drawings

The Contractor shall provide three securely bound sets of Operating and Maintenance Manuals together with three copies of as built drawings including full process and instrumentation diagrams. A full draft manual shall be provided prior to the issue of a Taking-Over Certificate with three copies of the final revision provided, at least one copy to be on CD-ROM.

The information provided with each manual shall include but not necessarily be limited to:

- Design specifications;
- Serial numbers of the package, the electrical motors and all individual components as applicable;
- All manufacturers' components design specifications, model numbers and information;
- Operating instructions for starting up, running and shutting down of all systems;
- Full instructions for adjustments and settings;
- Full commissioning and test records;
- Full lubrication instructions;
- Full maintenance manuals to enable the Employer to carry out their own maintenance;
- Full plant log and inspection and maintenance schedules;
- Full electrical schematics of the controls including all wiring diagrams;
- Function descriptions and automation software programmes and listings including a copy in electronic form;

- Full spare parts list for the complete package; and
- List of critical and recommended spares.

The final format of all such manuals and drawings shall be agreed with the Engineer prior to their preparation.

Drawings shall also be supplied as hard copies and also in electronic form. All plant layout and P&ID drawings shall be provided in AutoCAD or similar format.

5.13 Existing Equipment

Existing equipment to be reused and where necessary modified by the Contractor shall be inspected jointly by the Contractor and Engineer. Where the equipment to be reused requires repairs and/or maintenance beyond that which could reasonably have been foreseen by the Contractor, the Contractor and Engineer shall agree the extent of the additional work and the costs thereof. If during the course of the alterations to an item of existing equipment it becomes apparent that repair work is required, the Engineer and Contractor shall inspect the work and agree the extent of any additional work and the cost.

5.14 Documentation and Approvals

The Contractor shall allow 14 days for the approval by the Engineer of all drawings, schedules and documents as required under this Contract unless such lesser time is agreed in writing by the Engineer. The Contractor shall allow for up to four copies of each and every drawing and document necessary for the approval of the proposed plant and for the subsequent operation and maintenance of the plant. Electronic copies of CAD drawings shall also be provided in AutoCAD format.

5.15 Substitutions

All components and engineering specifications shall comply with the technical specification unless agreed to in writing by the Engineer.

Substitutions of alternative equipment or brands of component types shall be approved by the Engineer in writing prior to commitment and installation.

5.16 Industrial Relations

The Contractor shall keep the Engineer fully informed of all claims made or other industrial relations matters which may affect the Site or the Employer's activities and shall take all reasonable steps to avoid actions or inactions which will prejudice the Employer.

The Employer instructs the Contractor not to enter into any specific Site agreement, or redundancy agreements and shall not employ workers at the Site nor specifically for the Site nor specifically for this Contract but for general work at unspecified locations. Any actions in contravention of these preferences are likely to be prejudicial to the Employer and therefore not acceptable.

5.17 Quality Systems and Standard Compliance

The Contractor shall implement full Quality Management System procedures on all aspects of the Work from and including initial design to final documentation.

The Engineer reserves the right to arrange an independent assessment of the Contractor's or Plant Suppliers Quality Management System if quality systems procedures in use on the Contract are considered by the Engineer to be deficient.

5.18 Goods and Contractor's Plant

All Goods and mechanical plant used by the Contractor in the execution of the Works shall be of such type, size and shall be utilised in such a manner as the Engineer shall approve. The Engineer's approval to use mechanical plant will not be unreasonably withheld, but if in the Engineer's opinion, circumstances arise which make it desirable that the use of plant be suspended either temporarily or permanently, the Contractor shall change the method of performing the work affected and shall have no cause for claim against the Employer on this account nor shall there be cause for claim if any order by the Engineer results in the mechanical plant having to stand idle for a period of any duration whatsoever or having to be removed.

The Contractor shall use every possible means to prevent noise and annoyance to the inhabitants of the area in which the Works are situated, and all machinery must be of such design and so arranged as to be reasonably free from noise in operation. The Contractor shall have no claim for any charges involved in complying with the requirements of this clause.

5.19 Construction Photographs

Before commencing and during the progress on any part of the Works, the Contractor shall permit and if required, shall render assistance in the taking of such photographs as the Engineer may require.

5.20 Advertising

The Contractor shall treat the Contract and everything within it as private and confidential. In particular the Contractor shall not publish any information, drawing or photograph relating to the Works and shall not use the Site for advertising purposes except with the written consent of the Engineer and subject to such conditions as the Engineer may prescribe.

5.21 Existing Services

The Contractor is to leave all existing services, in place unless otherwise directed by the Engineer.

5.22 Protection of Works

Where required, the Contractor shall cover and protect the Works and all plant and equipment from inclement weather and damage as the Works proceeds. Any work, materials, plant or equipment suffering damage shall be made good at the Contractor's expense.

6 Specification - Introduction

6.1 Scope of Supply

The Contractor shall furnish all labour, materials and equipment required to design, manufacture, factory test, deliver to the Site, refurbish and recommission the four (4) existing generators at Wailoa power station.

The scope of work includes:-

- Pre-dismantling tests on the existing generators to obtain a baseline condition assessment.
- Dismantling and cleaning the generators.
- Clean, inspect, re-varnish, reapply semiconductor coating of the stators.
- Re-wedging all four stators.
- Clean, inspect and re-varnish the poles.
- Interchange the phase and neutral connections.
- Remove, inspect and replace if necessary (from station spares) the bearing pads.
- Refurbish any replaced bearing pads with new white metal.
- Remove the existing auxiliary shaft, PMG and exciter.
- Manufacture new stub shafts for the slip rings and speed monitoring equipment.
- Remove, inspect replace or refurbish the slip rings.
- Replace the slip ring to pole connections.
- Replace the brush gear and brushes.
- Replace the speed monitoring system and electrical overspeed device.
- Test the stator winding and core RTDs. Replace (as an option) any faulted RTDs.
- Replace all other instrumentation on the generators.
- Reassembly, testing and recommissioning.

Other contracts associated with the turbine generators will be proceeding in conjunction with this Contract. The Contractor is required to cooperate with the Employer and other contractors to help facilitate the smooth execution of the work. The other contracts include:-

- Turbine and governor rehabilitation.
- Turbine inlet valve rehabilitation.
- Replacement excitation system supply.
- Replacement generator 11kV system supply.
- Replacement generator 415V MCC supply.
- New diesel generator switchboard supply.
- Replacement generator control and protection system supply.
- Replacement powerhouse auxiliary transformer supply.
- Powerhouse crane refurbishment.
- Powerhouse building and services upgrade.
- Ancillary systems installation contract

6.2 Existing Generator Characteristics

Manufacturer	TIBB, WV200/130/8
In Service Date	1983
Rating	24,500 kVA, 0.85 pf
Voltage	11,000 volts
Phase	3
Speed	750 rpm
Poles	8 pole
Stator Temperature Rise	60ºC

Excitation Current	845 A
Excitation Voltage	115 Vdc
Stator Core Outer Dia.	2771mm
Stator Core Inside Dia.	2000mm
Air Gap	19mm
Stator Core Height	1300mm
Stator Slots	108
Insulation type	Micadur
Insulation class	F
Winding type	Double layer coil
Number of turns per coil	6
Number of parallel strands per coil	6
Number of parallel circuits per phase	4
Upper Combined Bearing	
Thrust bearing type	White metal, tilting
Thrust bearing No. pads	8
Guide bearing type	White metal, segmental
Guide bearing No. pads	12
Lower Bearing	
Guide bearing type	White metal, segmental
Guide bearing No. pads	4
Generator Air/Water Coolers	
Number of Coolers	4
Cooler Rating	120kW

Selected drawings and documents for the existing generators are included in Appendix A of this specification

7 Specification - General Requirements

The following sections and paragraphs written in the singular form for one generator shall apply equally to all generators, except where specifically indicated otherwise.

The basic materials and methods shall be in accordance with the Common Requirements Specification.

7.1 Submittals

Submittals shall be provided in accordance with the requirements of Section 1.3 of the Common Requirements Specification.

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7.2 Basic Design

The following documents shall be provided with the Contractors bid and shall include the following

- Narrative description of the refurbishment methodology proposed.
- Detailed programme of works
- A list of standards being used.
- Catalogue data and brochures indicating the main characteristics of the wedging system proposed.
- Catalogue data and brochures indicating the main characteristics of the replacement instrumentation.
- Catalogue data and brochures for the partial discharge monitoring system.
- Catalogue data and brochures for the vibration monitoring system.
- Catalogue data and brochures for the speed monitoring system.

7.3 Detailed Design

The following detailed design documents shall be provided:

a) Pre-Dismantling Test procedures.
b) Disassembly plan.
c) Stator NDT test procedures.
d) Stator cleaning methodology.
e) Re-wedging plan, including drawings and materials lists of replacement wedging system.
f) Phase and neutral cubicle reconfiguration methodology and drawings.
g) Partial discharge coupling capacitor details and installation drawings.
h) Rotor pole NDT test procedures.
i) Stub Shaft and Slip Ring Assembly drawings. Submit detail drawings of the stub shaft showing dimensions, materials, and bolting requirements. Drawings of any modifications to the stub shaft enclosure or removed exciter enclosure detailing access, lighting and view ports, slip rings and brush assembly.
j) Replacement slip ring and brush gear drawings and materials lists.
k) Bearing rehabilitation plan.
l) Detailed installation drawings and schematics for the speed monitoring equipment.
m) Detailed installation drawings and schematics for the vibration monitoring equipment.
n) Generator air cooler design calculations and drawings.
o) Reassembly plan
p) Recommissioning plan, detailing the activities that are the responsibility of the Contractor. This shall include a detailed schedule for the Contractors activities.

7.4 Records and Instructions

The following records and instructions shall be provided:

a) Factory Test Reports.
b) Type Test Reports.
c) Instructions:
    - Factory Assembly and Testing Procedures
    - Handling and Storage Instructions
    - Installation Instructions.
    - Operating and Maintenance Instructions.
    - Field Testing, Pre-Commissioning, Commissioning Procedures of Check-Out, Start-Up, Initial Operation and Testing.
d) As built drawings.

7.5 References, Standards and Codes

The Contractor shall comply with requirements of the Common Requirements Specification and the latest revisions of applicable industry standards.

8 Specification - Description of Works

8.1 General

This Section of the specification details the extent of work to be carried out on each generator. Note that the exact scope of work to be carried out on each individual machine may be adjusted to take into account factors determined during the pre-dismantling tests, detailed inspections, test results, or identified on preceding generators.

8.2 Pre-Dismantling Tests.

Prior to the shutdown of any of the turbine generators, the Contractor shall undertake pre-dismantling tests on all four generators. The purpose of these tests will be to establish the candidate machine for the first strip down and refurbishment. At present, based on the turbine condition it is expected that this will be Unit 4.

The Contractor shall:-

- Test the measurements from the stator, cooler and bearing RTDs to verify that the measurements displayed on the Unit control panel meters are correct. At present Unit 1 is occasionally reading temperatures up to 150°C and the accuracy of the RTDs and associated circuitry has been questioned.
- Once verification of the temperature sensors has been completed install a datalogger to log all temperatures associated with each unit, plus ambient temperature and generator MW output. Sampling rate shall be no less than every five minutes and the measurement period shall be at least 48 hours per machine. Log files in xls or csv format shall be provided to the Engineer.
- Undertake a thermal imaging inspection of the in-service generator. The inspection shall cover the terminations, stator enclosure (external) and brush gear.
- Insulation resistance and polarization index tests shall be made on each phase as described in IEEE 43. In all cases, the phases not under test shall be solidly grounded. Tests shall be made at or above 2,500 volts dc.
- Each individual phase of the winding shall be high potential tested with the phases not being tested solidly connected to ground. The test shall be in accordance with ANSI C50.10 and IEEE 115. The test value shall be 17.25 kV ac rms for a period of one minute.
- A controlled dc overvoltage test shall also be performed on each phase of the winding to provide baseline data for future maintenance tests. The test shall be the Graded Time Method performed in accordance with IEEE 95. A kV dc voltage vs. microamp plot shall be furnished for each phase
- The turbine and generator shafts alignment and runout shall be determined in accordance with ANSI/IEEE 810, "Standards for Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances."
- Inspect the spare generator bearings held in store by the Employer to confirm that they are suitable for service.
- Inspect and test the spare stator coils held by the Employer to confirm that they are suitable for service if required.
- Prepare a detailed test report presenting the findings of the tests undertaken. Any items of concern shall be clearly noted in the report, along with the Contractors recommendations for corrective works.

Should the testing identify additional work that is recommended, the Engineer will issue formal Variation requests to cover the amended scope of the work to be carried out. This shall follow the requirements of the Particular Conditions clause 13.3.1.

8.3 Dis-assembly.

Once released from service the Contractor shall dismantle the generator following the procedures outlined in the TIBB Generator O&M Manual Section 4.5.

Dismantling shall include:-

- Removal of the PMG.
- Removal of the exciter, stub shaft and brush gear.
- Removal of the upper bearing.
- Removal of the stator
- Removal of the lower bearing.
- Removal of the rotor.

Prior to disassembly the Contractor shall label and/or matchmark all adjacent components that shall be reused and stamp the unit number and component identification number to facilitate reassembly. The numbering system shall be documented and "approved" by the Employer to ensure components will be reassembled in the same location. The disassembly sequence and procedures shall be documented by sketches, checklists, and photos. Unless suitable for reuse, previous match marks shall be voided by some method to identify that they are not being used.

The disassembly procedures outlined in the TIBB manuals may need to be augmented or modified by the Contractor to suit the actual conditions during disassembly. Any modifications to the written procedures shall be discussed with and "approved" by the Employer prior to proceeding with the modified procedures.

Prior to disassembly the Contractor shall prepare step-by-step disassembly procedures for review, including checklists and data collection sheets.

The Contractor shall furnish all labour, tools, supplies, bracing, lifting equipment, supports, and all other items or materials necessary to disassemble the equipment in a thorough, neat, and skilful manner. Any special tools that were provided as part of the original generator supply may be used by the Contractor provided that the Contractor signs for all tools utilised on 'check-out' and 'check-in' from the Employers stores.

Great care shall be taken by the Contractor during disassembly and handling of the components so as not to damage any components or other units that will be reused or remain in operation.

As parts are removed from the unit, they shall be marked and labelled in a manner to positively identify where they go and stored in a manner so that they can be conveniently located during reassembly. Provide storage bins for small parts, such as nuts and bolts, and label the contents. Provide tags for large or bulky parts. Any items that are missing or damaged at the time of disassembly shall immediately be notified to the Employer. The Contractor shall be responsible for replacing any items that are misplaced or lost between then end of disassembly and reassembly.

The Contractor shall record the location and thicknesses of any shims required to level or align the equipment as they become disassembled.

Once removed the PMG, exciter and stub shaft shall be cleaned, placed in plastic storage bags along with desiccant pellets, and crated for storage by the Employer.

The remaining large parts shall be carefully placed in the powerhouse loading bay area ready for further inspection and rehabilitation.

On completion of the disassembly, the scope of the work will be reviewed. The Engineer will issue formal Variation requests to cover the amended scope of the work to be carried out. This shall follow the requirements of the Particular Conditions clause 13.3.1.

8.4 Stator Rehabilitation.

The following rehabilitation/testing of the stator shall be conducted (not necessarily in the order presented):-

8.4.1 Inspection, Cleaning and NDT

The Contractor shall visually and non-destructively examine the stator frame after disassembly. Non-destructive examination shall include 100% PT or MT and 100% UT examination (to the extent practicable) of all castings, forging, weldments, focusing on areas subject to high and/or alternating stresses. The Contractor shall weld repair any deficiencies in accordance with certified and approved welding procedures and welding operators, and shall re-examine all repaired areas using the same NDT procedures and acceptance standards.

The Contractor shall undertake off-line partial discharge measurements using the method described in section 10.1 of IEEE 1434.

The stator core condition shall be assessed using the electromagnetic core imperfection detection method “EL-CID”.

The core compression bolt tightness shall be checked and, if necessary, adjusted to the manufacturers design torque (90 kg.m).

The Contractor shall carefully inspect the windings for signs of damage or symptoms of insulation deterioration.

Any unusual contamination, cracks, tracking marks, white powder, grease, rust, or foreign particles shall have the location clearly recorded and, if practicable, a sample of the contaminant taken for possible analysis to determine whether the contaminant is a by-product of partial discharge activity or fretting from rubbing.

The Contractor shall prepare an assessment report outlining the NDT test results and observations made, the possible explanations for any abnormal results or observations and the Contractors recommendations and expected costs for any additional work. This report shall be presented within two weeks of the stator being removed. If there is evidence of slot discharges then the Contractor shall investigate the injection of a semi-conductor material to restore the stress gradient system. The Contractor shall provide a quotation for this work with their tender as an optional price

A meeting shall be held between the Engineer, Employer and Contractor to discuss the report, and following the meeting the Employer may instruct the Contractor to undertake additional rehabilitation work on the stator.

Following the inspection the stator bore and exposed windings shall be cleaned by wiping down with cloths dampened using an approved solvent, such as manufactured by Ecolink. The stator cooling channels shall be carefully inspected for blockages and cleaned as necessary using compressed air.

The end windings shall have any loose ties or blocks corrected. Any cracks in the insulation shall be repaired with compatible materials. The stress grading coating shall be re-applied.

8.4.2 Re-wedging

A new wedging system comprising spring-type filler material; front filler and stator slot wedge shall be installed.

The Stator slot wedges shall be manufactured from NEMA Standard LI1, Grade GIl material. The slot wedge cross sectional shape shall match the wedge groove shape of the stator laminations. Wedge width shall result in a snug, sliding fit when placed in position prior to driving over top fillers.

Top fillers shall be furnished in a variety of thickness to ensure that a proper thickness combination is available to produce a satisfactory radial wedging pressure. The wedging pressure shall be at least 150% of the maximum opposing radial electromotive forces produced on the coil assemblies.

A repeatable method for checking spring-type filler material deflection shall be provided. At a minimum, it shall allow the deflection to be measured at three locations in each slot. The initial deflection shall be recorded and furnished to Employer. The Contractor shall furnish all gauges and other equipment required to determine the total spring deflection and shall furnish instructions for use.

The check wedges shall be located at the quarter points of each slot. End wedges shall be secured in place to prevent axial movement or migration of slot wedges or wedge fillers, but in no case shall epoxy be used to secure the wedges. Wedges shall be furnished with cutbacks at the cooling air passages. These cutbacks shall be designed to enhance the airflow.

Following installation of the new wedging system the tightness of the wedges shall be determined using a wedge tightness detector. The results shall be recorded for future reference and handed to the Employer.

8.4.3 Stator RTD Installation

The Contractor shall provide a total of twelve RTD sensors to replace any faulted sensors identified during testing. The sensors shall be flat, laminated type, with 250mm long sensing element, in accordance with ANSI C50.10. Any replacement sensors shall be located between the outermost coil and the wedging system in the same slot as the faulted sensor.

8.4.4 Phase/Neutral Terminal Reversal

The line and neutral terminal equipment are located in a common cabinet on the downstream side of the generator as shown on TIBB drawing UQR00214. The Contractor shall reverse the generator phase and neutral terminals by exchanging the stator line terminal equipment and stator neutral terminal equipment. The extent of work includes:-

- Measuring the existing cabinets for “as built” dimensions.
- Stripping out the line and neutral cabinet equipment.
- Relocating the support bars.
- Reinstalling the line and neutral bars, CT’s, VT’s, earthing transformer and other items. The completed arrangement shall have phasing Z, X, Y, W, V, U when viewed from the front of the cabinet.
- Redraw and as built drawing UQR00214 using CAD.

8.4.5 Partial Discharge Analysis System

The components of a Partial Discharge Analysis (PDA) system internal to the generators shall be designed, provided, and installed. The system shall include coupling capacitors, leads, and termination cabinet for monitoring the condition of the stator winding without a service outage. The system shall include protective devices and circuitry as necessary to prevent circulating currents and unsafe voltages from appearing at the termination cabinet. The system shall be designed to interface with a portable discharge analyser such as the Iris Power Engineering Inc. Model PDA-IV, or equal.

Six 80pF coupling capacitors shall be furnished and installed in the winding, two in each phase. The capacitors shall be of the potted mica type. The capacitors shall be Iris Power Engineering Epoxy-Mica Coupler, or “approved” equal.

Leads shall be furnished to go from the coupling capacitors to the termination cabinet. The leads shall be RG58A/U coaxial cable. Each lead shall be terminated with a BNC connector.

A termination cabinet shall be provided sized to accommodate all coaxial cable leads, BNC connectors, terminal boards, and termination and protective devices. Each coaxial cable shall be terminated with a 670 ohm, 1 watt, resistor and a gas discharge surge arrester at the rear of the BNC.

8.5 Rotor Rehabilitation.

8.5.1 Poles

The rotors shall be closely inspected. In particular the inter-pole connections, damper connections and fan blades shall be checked for any signs of stress or fatigue damage.

The poles shall be removed from the rotor and the Contractor shall visually and non-destructively examine the rotor and pole connection area after disassembly. Non-destructive examination shall include 100% PT or MT and 100% UT examination (to the extent practicable) of all castings, forging, weldments, focusing on areas subject to high and/or alternating stresses.

The condition of the pole tensioning bolts and damper windings shall be checked.

Any items of concern shall be advised to the Employer promptly along with the Contractors recommendations for corrective works.

Each pole shall be thoroughly cleaned and given the following tests:-

- Insulation Resistance using a 1500V DC test set
- High Voltage AC Withstand (1.5 kV for one minute).
- Turn-to-Turn Tests to identify short circuits between the turns of the field winding. This test shall be performed by subjecting the pole field winding to a short duration impulse voltage and measuring the response using an oscilloscope. The second pole response shall then be checked against the first pole to confirm that the response curve is identical. In order to check that a fault would be detected, a deliberate short circuit shall placed between two coils and the waveform compared against the previous ‘healthy’ measurements. Any poles that have a different response from the other poles shall be further investigated for shorted turns.

Any pole identified as having shorted turns shall be dismantled, inspected and reinsulated using Nomex® or approved equivalent insulating paper. Any cracked joints in the field winding shall be repaired by brazing. The Contractor shall provide a quotation for this work with their tender as an optional price

All poles shall be painted with Glyptal® red alkyd.

The Contractor shall prepare an assessment report outlining the NDT test results and observations made, the possible explanations for any abnormal results or observations and the Contractors recommendations and expected costs for any additional work. This report shall be presented within two weeks of the rotor being removed.

A meeting shall be held between the Engineer, Employer and Contractor to discuss the report, and following the meeting the Employer may instruct the Contractor to undertake additional rehabilitation work on the rotor.

8.5.2 Rotor Stub Shaft

Removal of the existing auxiliary shaft, PMG and exciter will necessitate installation of a new stub shaft and slip ring assembly. The Contractor shall furnish and install new stub shaft assemblies complete with mountings for the slip rings and speed sensing toothed wheel.

The stub shaft shall be of sufficient size and minimum runout to operate at any speed up to full runaway speed without vibration or objectionable distortion. It shall be the responsibility of the Contractor to match the coupling flange of the existing rotor hub and the mounting of the slip rings speed signalling devices.

A fabricated steel cover and support shall be provided to enclose the stub shaft and provide support for the stationary parts of the slip rings and speed signal device. The cover shall be supported on the existing structural supports of the removed exciter housing. It shall cover all voids left by removal of the exciter housing. The cover shall incorporate a carbon dust collection system.

Ventilation and hinged access covers with latches for maintenance and inspection shall be provided. Lighting shall also be provided for brush maintenance. The lights shall be switched from an approved location near the access point.

8.5.3 Slip Rings, Brush Gear and Field Connections

Removal of the existing auxiliary shaft, PMG and exciters shall require of new slip rings onto the new stub shaft and provision of new brush gear and field connections.

New slip rings shall be of identical thickness (40mm) and outside diameter (595mm) to the existing slip rings. The service life of the slip ring shall not be less than 20 years, and the maximum abrasive wear over that period shall be 2mm. The slip ring assembly shall be so designed that its surface can be repolished at the Site.

The Contractor may consider re-using the existing generator slip rings. If this option is adopted the slip rings shall be checked for pitting, eccentricity and overall diameter. If the diameter of the slip rings is less than 593mm (equivalent to 1mm or 50% of permitted wear), and/or if there is substantial pitting (<1mm depth) the Employer shall be advised. At this point the Employer may elect to instruct the Contractor to replace the slip ring instead of refurbish.

The slip rings shall be machined to restore their original finish. The Contractor shall take care so as to remove the minimum amount of parent material possible. On completion of machining the Contractor shall record the final diameter for Employer records.

The slip rings shall be mounted above the rotor in the new stub shaft housing. They shall be sufficiently spaced or barriered and insulated with Class F insulation. The Contractor may re-use existing mounting hardware subject to it being inspected for damage prior to re-use. In any case the tube for insulating where the lower slip-ring connection passes through the upper slip ring shall be replaced, along with the insulation between the slip rings and shaft.

New brush gear shall be provided and mounted on the new stub shaft cover assembly. Brushes shall be the same type as existing (ten of EG340 32mm x 32mm x 65mm). Brushes shall be arranged to allow inspection while the generator is running without removing the shroud and to minimize the possibility of an operator causing a short circuit between slip rings while changing or adjusting the brushes. The brush holder shall be arranged so that the brush can be easily and safely removed and reinserted into the holder during operation. The brush pressure acting on the ring shall be constant at 18g/cm^2 ±10% without requiring adjusting during the lifetime of the brush. The structure and arrangement of the brushes and holders shall facilitate ventilation.

New field leads shall be furnished and installed from the new slip rings to the field coil termination points. Insulation for the rings and leads shall be vibration, oil and moisture resistant.

8.5.4 Speed Measuring Equipment

The Contractor shall provide a generator speed pickup and monitoring system which shall provide speed reference signals to the governor and unit control system, plus overspeed alarm and trip outputs.

The speed measuring equipment shall consist of a toothed wheel mounted onto the rotor stub shaft, 4 pulse initiating proximity pick-ups and a speed monitor. Two of the proximity pick-ups shall be used for speed signalling to the governing system. The other two pick-ups shall be used for by the speed monitor for speed reference to the unit control system, creep detection and speed indication. The speed sensing system shall be able to detect complete stop and creeping of the unit.

The speed sensing system shall be capable of operating without damage at the maximum turbine runaway speed and shall be designed, mechanically and electrically, for continuous operation. All electrical circuits of the speed sensing system shall be wired to terminal blocks in a box located on the stub shaft cover.

Creep-detection equipment for monitoring unit creep in automatic or manual mode of operation shall be included in the speed monitor system, and it shall be activated by sensing an angular displacement of 3 degrees or less independent of the rate of movement.

The speed monitor shall include at least six independent clean contacts for signalling to the plant control and protection systems. Each contact shall be adjustable to operate for any speed setpoint between 0 and 150% of the generator rated speed. A further two contacts shall be provided for creep indication. The speed monitor shall also feature a 4-20mA speed signal for use by the unit control system.

A centrifugal overspeed switch assemblies, with 3 electrically independent, ungrounded, normally-open contacts, shall be fitted to the end of the stub shaft. The range of speed switch operation shall be adjustable between 115% and 150% of rated speed, and shall be able to operate at speeds up to the maximum runaway speed.

8.5.5 Bearing Rehabilitation.

The generator thrust, upper guide, and lower guide bearing pads shall be removed and inspected. If any of the pads white metal surfacing show evidence of cracking, failure of bond between white metal and backing pad, widespread wiping or insufficient white metal thickness then the pad shall be replaced with a spare from the Employers stores.

Any pads that have been rejected for re-use shall be sent to the Contractors factory to have new white metal surfaces applied.

All pads shall be manually scraped with a herring bone pattern prior to reinstallation.

The thrust bearing runner and guide bearing journals shall be inspected for damage. Minor damage shall be hand dressed using emery paper. Repair options for any major damage shall be presented to the Employer for consideration.

The condition of the upper bearing insulation shall be checked and the insulation replaced if necessary.

The Contractor shall inspect the bearing high pressure oil piping system, including the insulating segment, and identify any remedial works required for the Employers consideration.

The Contractor shall remove, clean (internal and external) and pressure test the bearing oil coolers. The coolers shall be subjected to a test pressure of 10 Bar for thirty minutes. Any coolers that leak shall be repaired or replaced at the Employers discretion. The Contractor shall replace all of the existing bearing gate valves and orifice plates and replace with isolating/regulating valves suitable for balancing flows in the various coolers.

The Contractor shall provide new replacement oil for the bearings.

8.6 Generator Air / Water Coolers

The Contractor shall supply one complete set of four generator coolers for one generator. Additional coolers may be added to the scope of Contract following the first machine shutdown

The generator coolers shall be rated and dimensioned in accordance with TIBB drawing UW302516.

The air coolers shall be of the plate-fin type with stainless steel/cupro-nickel tubes expanded into and fixed to non-ferrous corrosion-resisting tube sheets. The water boxes shall be non-ferrous and constructed with removable cover plates to permit access to all tubes, and they shall be arranged to permit free thermal expansion and to permit removal of any cover for inspection or 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. Automatic air vents shall be provided at the top of each cooler. The air vents shall be connected through valves to a common header.

The discharge header shall have a vented standpipe to ensure that coolers will always be full of water. A gauge cock with a 6 mm tapered-pipe-thread female connection shall be provided at the inlet and outlet of each cooler for use with pressure gage. Handling devices and an air blow off device shall be provided on each cooler.

The Contractor shall replace all of the existing air cooler gate valves and orifice plates and replace with isolating/regulating valves suitable for balancing flows in the various coolers. The valves shall have provision for fitting a differential pressure type setting tool, and one handheld electronic measuring tool shall be provided for all four generators.

8.7 Generator High Pressure Oil System

The Contractor shall test the performance of the HP Oil System in accordance with the TIBB maintenance instructions. While the thrust bearing pads are removed, the Contractor shall plug the HP oil pipe at each bearing end, and pressure test the system to a pressure of 300 bar. Any leaks in the system shall be attended to.

The condition of the distribution pipework, non return valves, couplings and insulating connections inside the upper bearing assembly shall be carefully assessed and the Employer advised of any recommended refurbishment works.

The HP oil system filters shall be replaced and the oil system flushed and refilled. The Contractor shall provide the replacement filters and oil.

8.8 Generator Jacking System

The Contractor shall test operation of the jacking system. The O-ring seals in the jack shall be replaced.

The Contractor shall test operation of the limit switches and report any deficiencies to the Employer.

8.9 Instrumentation Upgrade

Most existing instrumentation on the generator is to be replaced with new, modern equivalents. In addition, some new instrumentation is to be added. All instrumentation shall be connected to existing generator terminal boxes JB or JD as appropriate. The Contractor shall verify all specified probe lengths etc. prior to ordering new instruments.

8.9.1 Stator Winding Temperature

As noted in Sections 8.2 and 8.4.3 the existing stator RTDs shall be tested for correct operation and a total of ten (10) RTDs shall be provided to replace any faulty items found.

8.9.2 Stator Air/Water Cooler Temperatures

The existing warm air (1 of) and cool air temperature (2 of) sensors shall be removed. New 3 wire Pt100 RTD sensors shall be fitted to the cold air and warm air side of all four coolers on each generator. The sensors shall be duplex type housed in an IP54 rated instrument housing, with probe length 250mm. The Contractor shall supply brackets suitable for mounting the RTDs on the cooler and shall provide shielded instrument cable to junction box JD.

A thermowell and RTD shall be fitted onto the 2" cooling water discharge pipe from each cooler. The sensors shall be duplex type housed in an IP54 rated instrument housing. The Contractor shall provide shielded instrument cable to junction box JD.

8.9.3 Stator Air/Water Cooler Flows

The existing ASEA TIVG 50-F3 flow meters shall be removed and replaced with a flanged spool piece sized to match the meter dimensions. Thermal dispersion type flow meters shall be fitted onto each spool piece to measure the discharge from each cooler. Meters shall be of Weber manufacture or approved equal with flow measurement range from 0 to 200l/min. The 4-20mA output from each sensor shall be terminated in junction box JD using screened instrument cable.

The Contractor may install the thermowell pockets for the cooler discharge water temperature onto the same spool piece,

8.9.4 Bearing Oil Temperatures

The existing lower guide bearing and upper combined bearing oil temperature sensors shall be removed. Two new 3 wire Pt100 RTD sensors shall be fitted to the lower guide bearing reservoir and two to the upper combined bearing oil reservoir on each generator. The sensors shall be duplex type housed in an IP54 rated instrument housing, with 1/2G threaded connection. The Contractor shall provide shielded instrument cable to junction box JB (lower bearing) and JD (combined bearing).

The lower guide bearing oil RTD shall have probe length of 150mm.
The upper combined bearing oil RTD shall have probe length of 250mm.

The additional sensor on each bearing enclosure shall be mounted opposite the existing sensor using a similar mounting arrangement. Final position shall be confirmed with the Employer prior to modifying the existing bearing housing.

8.9.5 Bearing Oil Level

New bearing oil level transmitters shall be fitted to the lower guide and upper combined bearings. The level transmitters shall be capacitive probe type – E&H Multicap with rod probe or similar. The transmitters shall be mounted on the bearing top cover and shall be selected to measure over a range ±50mm from the design oil level shown on the TIBB drawings. The 4-20mA output from each sensor shall be terminated in junction box JB (lower), JD (upper) using screened instrument cable.

The existing oil level switch assemblies shall be cleaned and checked for correct operation.

8.9.6 Bearing Temperatures

The existing capillary type bearing temperature alarm and trip switches fitted to two of the upper guide pads, two of the thrust pads and two of the lower guide pads shall be removed and replaced with RTDs.

The existing RTDs fitted to two of the two of the upper guide pads, two of the thrust pads and two of the lower guide pads shall be removed and replaced with new RTDs.
Note that the new RTDs replacing the existing capillary sensors will need to be slightly different to the other RTDs and a method of securing to the pad will need to be fabricated. Refer to drawing UW404310 in part 9 of the generator O&M manual for details of the existing capillary sensors and drawing UW404309 for details of the existing RTDs.

New RTDs shall be three wire Pt100 duplex type connected by oil proof, armoured cable to an IP54 rated junction box located on the bearing housing. The Contractor shall provide shielded instrument cable to junction box JB (lower bearing) and JD (combined bearing).

8.9.7 Bearing Cooler Temperatures

RTDs shall be fitted onto the existing thermowells on the cooling water discharge pipe from the upper combined bearing and lower guide bearing coolers. The sensors shall be duplex type housed in an IP54 rated instrument housing. The Contractor shall provide shielded instrument cable to junction box JB (lower bearing) and JD (combined bearing).

8.9.8 Bearing Cooler Flows

The existing ASEA TIVG 25-R5 (lower) and TIVG 50-F3 (upper) flow meters shall be removed and replaced with flanged spool pieces sized to match the meter dimensions. Thermal dispersion type flow meters shall be fitted onto the spool piece to measure the discharge from the upper combined bearing (2”) and lower guide bearing (1”) coolers. Meters shall be of Weber manufacture or approved equal with flow measurement range 0 – 100 l/min. The 4-20mA output from each sensor shall be terminated in junction box JB (lower) and JD (combined) using screened instrument cable.

8.9.9 Main Cooling System Temperatures

New thermowells shall be fitted on the existing 4” main cooling water return pipe as close as practicable to the generator and on the 4” supply pipe immediately before the cooling water pumps (refer existing drawing UW103517). RTDs shall be fitted into these new thermowells and onto the existing thermowell on the common discharge pipe from the cooling water pumps. The sensors shall be Pt100 duplex type housed in an IP54 rated instrument housing. The Contractor shall provide shielded instrument cable to junction box JB.

8.9.10 Main Cooling System Pressure

The existing pressure switch at the discharge from the cooling water pumps shall be removed and replaced with a pressure transmitter. The transmitter shall be of E&H Cerabar or approved equal with pressure measurement range 0 – 10 bar. The 4-20mA output from the sensor shall be terminated in junction box JB.

8.9.11 High Pressure Oil System Pressure

The existing pressure switch on the HP Pump common header shall be replaced with a new equivalent. The Contractor shall provide shielded instrument cable to junction box JB.

8.9.12 Ambient Temperature

An ambient temperature sensor shall be mounted on the outside of the generator enclosure. The sensor shall be duplex type Pt100 housed in an IP54 rated instrument housing. The sensor shall be spaced off the enclosure so as not be unduly affected by heat radiated off the enclosure.

8.10 Vibration Monitoring

The Contractor shall design, furnish, install, test and commission a complete and integrated, vibration monitoring system. The system shall be installed, configured and optimized to provide complete machinery protection, automated transient data gathering during unit start-ups and shutdowns, constant machine surveillance during steady-state operations and historical database collection for long term trending and machinery management.

The system shall provide displays, software alarms, plots, graphs and vital machine information that allow users to continuously monitor and analyse machine condition.

Data contained in the stand-alone vibration monitoring system database shall be made available as input to the plant control system. The vibration monitoring system shall be configured so all unit Data is correlated in a logical manner and made available for complete, proper and rapid analysis of the unit behaviour.

The system shall provide machine data measurements, permit static measurements and frequently and randomly monitor the condition of all parameters without requiring a service outage. Magnetic field, dust, oil, sediment and carbon particles found in the sensor measuring gap shall not alter the system measurements. The system shall include software for complete diagnostic analysis. The Contractor shall recommend alarm settings for initial operation.

The system shall be as manufactured by VibroSystM or alternative approved by the Employer. The installation and set-up of the vibration monitoring system hardware and software shall be supervised by the manufacturer representative.

Each Unit shall be provided with one vibration monitor and sensors. The vibration monitor unit shall be located on the generator floor and shall include inputs for the monitoring sensors; discrete alarm and trip outputs for the unit control and protection system; analogue outputs for the unit control system, and digital communications to the master diagnostic server.

Displacement type sensors shall be provided for measurement of shaft runout in X/Y pairs, 90 degrees apart, as close as practical to each guide bearing.

Accelerometer type sensors shall be provided for measurement of vibration in non-rotating parts of the bearings. The accelerometers for each guide bearing shall be provided in X/Y pairs in the same planes as the shaft runout sensors.

One set (x-y) of displacement and accelerometer type sensors shall be provided for the turbine bearing on each unit. These sensors will be installed under another Contract.

All sensors shall be provided with accompanying cables, conduit, and input hardware for the vibration monitor.

All vibration signals shall be wired into the vibration monitor for correlated analysis. The signals shall be re-transmitted from the vibration monitoring system via 4-20 mA signals to the unit control system.

All bearing radial vibration probes shall be attached to a rigid, non-vibrating structure and shall provide a reliable representation of true shaft motion.

The Vibration Probes shall be immune to shaft currents and electrical run-out noise, and mounted as close to the horizontal centreline of the generator guide bearings and the turbine guide bearing as possible. Mounting structure details shall be submitted to the Employer for approval.

The system shall include a master diagnostic server with software for complete diagnostic analysis of all four Units. The software shall include polar view orbit of the rotor shaft referenced to the actual rotor position showing the location of all poles and shall be capable of displaying run-out values referred to

the pole position for easy unit balancing capability. The master diagnostic server shall by VibroSystM ZOOM or similar approved by the Employer. The server shall be located in the Employers control room.

8.11 Reassembly

Prior to reassembly the Contractor shall prepare step-by-step reassembly procedures for review, including checklists and data collection sheets for adjustments and documentation of measurements.

The generator shall be reassembled in accordance with these Specifications, TIBB Generator O&M Manual Section 4.5, applicable drawings, written instructions prepared by Contractor, and with applicable codes and standards specified herein.

Reassembly procedures may need to be augmented or modified by the Contractor to suit the actual conditions during reassembly. Any modifications to written procedures shall be discussed with and agreed to by the Employer.

The Contractor shall furnish all labour, tools, supplies, bracing, lifting equipment, supports, and all other items or materials necessary to disassemble the equipment in a thorough, neat, and skilful manner. Any special tools that were provided as part of the original generator supply may be used by the Contractor provided that the Contractor signs for all tools utilised on ‘check-out’ and ‘check-in’ from the Employers stores.

The equipment and all of its components shall be placed with great care and accuracy and shall be correctly aligned to provide an installation consistent with the close tolerances used in the manufacture of the equipment. Contractor shall establish and maintain suitable control for the proper elevations and centrelines to which equipment is to be set.

Upon completion of all specified repairs, reassemble the unit basically in reverse order of the disassembly procedure. Clean all disturbed components and parts prior to reassembly. Reassemble the generator as required to provide a satisfactorily operating unit.

In the course of reassembly, repeated careful checks of alignments and levels, fits, clearances, concentricity, and trueness shall be made. Provide illustrated check sheets and record thereon all installation measurements. Such records shall be signed by the Contractor and Engineer, and copies shall be furnished to the Employer.

The Contractor shall make all adjustments, level, align, check, rebalance, redowel (tapered dowels may be reused, straight dowels shall be replaced) and torque as specified, required, or approved.

- Unit balancing.
- Shaft runout.
- Bearing clearances.
- Seal clearances.
- Generator air gap.
- Sealing Between Mating Surfaces.

The turbine and generator shafts alignment and runout shall be measured in accordance with ANSI/IEEE 810, "Standards for Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances." and adjustments made as necessary to meet the specified tolerances. Replacement gaskets and O-ring seals shall be provided for all connections designed to have gaskets or seals. For reassembled existing items, with mating surfaces that are exposed to liquids and that do not have gaskets or seals; use Loctite Gasket Eliminator No. 504 or equal on the mating surfaces.

Any burrs, sharp edges, nicks or gouges found on mating components shall be removed. The Contractor shall include a procedure for removal of burrs, sharp edges, nicks and gouges in the disassembly/reassembly procedures.

Tighten or preload fasteners used in major connections using a hydraulic tensioner if possible, otherwise using a hydraulic torqueing device. Preload fasteners to 80 percent of material yield strength, unless the TIBB instructions or Contractor-provided calculations demonstrate otherwise. To the maximum extent possible, verify bolt/fastener tension by measurement of elongation. Hold nuts, heads of bolts, and fasteners for major connections in place by approved locking devices such as suitable lock bars tack welded to the item being fastened. The use of "Locktite" or similar materials is not permitted. Do not tack weld to the nut or head of the bolt.

Measure and record all fastener torque or elongation readings (including intermediate settings) of all major bolted connections during reassembly. Submit the proposed torque or elongation for each fastener of major connections for review.

After reassembly and prior to starting, perform shaft plumb, straightness, alignment and runout checks, and alignment and position measurements. It is essential that an oil film be established on the thrust bearing running surfaces prior to any shaft rotation or lateral movement of the shaft. All measurements shall be recorded as previously done and submitted and approved, prior to starting the unit.

The Contractor shall furnish fresh filtered lubricating oil for the Unit. The type of oil 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. All oil shall be supplied by the Contractor, and shall be one of the following types (or exact equivalent)

- Shell Turbo Oil 33 5.2 E / 50°C.
- BP Energel h1 100 4.7 E / 50°C.
- Mobil Heavy Medium Oil 4.9 E / 50°C
- Teresso 52 5.2 E / 50°C

Following reassembly of the cooling system the Contractor shall thoroughly flush the cooling system prior to refilling with fresh filtered water and corrosion inhibitor. The corrosion inhibitor shall be ALFLOC 2000 and shall be mixed to the concentration required in the TIBB O&M manuals.

8.12 Recommissioning

Recommissioning of the turbine and generator will be undertaken primarily by the Employer and Engineer with supervision being provided by the various contractors as applicable to their scope of work.

For the generator the Contractor shall be responsible for:-

- Checking the correct operation of all new generator instrumentation including working with the control system installation contractor conduct loop tests. The Contractor shall be required to manipulate all field devices (including analogue devices), and take manual readings, in order to verify the operation and accuracy of all generator instruments.
- Testing and balancing the generator cooling water system.
- Supervising bearing heat run tests.
- Testing and commissioning the bearing vibration monitoring system, including setting all alarm and trip set-points.
- Balancing the generator rotor.

The overall sequence for recommissioning each turbine generator will follow the following general structure. The Contractor will be required to have at least one suitably experienced technician on site during the entire commissioning procedure.

8.12.1 Static Testing

Activity	Responsible Party
Inspection for completeness.	Each Contractor for their work area

Inspection of all the hydraulic conduits and removal of any foreign bodies.	Each Contractor for their work area
Point to point wiring tests.	Each Contractor for their work area
All terminations checked for tightness.	Each Contractor for their work area
Insulation resistance checks on all equipment.	Each Contractor for their work area
2 kV rms power frequency withstand test on all control and protection wiring.	Each Contractor for their work area
High current resistance checks across all high voltage joints (Ductor test).	Each Contractor for their work area
Correct settings applied to all protective devices.	Control system Installation Contractor
Plant control system software SAT tests.	Control system Installation Contractor assisted by each Contractor for their work area.
Measurement of bearing and seal clearance.	Each Contractor for their work area
Hydrostatic tests.	Turbine Contractor
Pressure tests in the governing system, check of oil levels and of the conditions of all oil filters and filtering systems	Turbine Contractor
Pressure tests in the cooling water system.	Generator Contractor
First fill of all lubricating and hydraulic oil.	Turbine Contractor Generator Contractor
First fill of cooling water system.	Generator Contractor
Verification of the correct operation of governor HPU.	Turbine Contractor
Verification of correct operation of HP Oil system.	Generator Contractor
Verification of correct operation of cooling water system.	Generator Contractor
Operational tests of all balance of plant equipment.	Each Contractor for their work area

8.12.2 Pre-Commissioning Tests

The pre-commissioning tests shall include pre-start and closing devices checks:

8.12.2.1 Dry Tests

These tests shall include:

Activity	**Responsible Party**
Adjustment of dry opening and closing times of turbine needles and deflectors to calculated settings.	Turbine Contractor
Adjustment of dry opening and closing times of main inlet valve to calculated settings.	Turbine Contractor
Confirm that the shutdown circuits function correctly by	Control System Installation Contractor

simulating each and every plant protective trip event and verifying correct operation of the turbine shutdown systems, inlet valve closing systems and generator circuit breaker trip (the generator circuit breaker shall be racked out during these tests).	assisted by each Contractor for their work area.
Unit Control System start up sequences	Control System Installation Contractor assisted by each Contractor for their work area.

8.12.2.2 Wet Tests

These tests shall include:

Activity	Responsible Party
Verify that the needle leakage is within acceptable limits.	Turbine Contractor
Check the opening and closing times for the inlet valve and confirm that they are as expected.	Turbine Contractor
First run operation of the turbine generator. During the first run, the turbine generator shall be "bump started" by manually opening the needles to a small opening for a few seconds. The unit shall be permitted to rotate and observed for any unusual readings, measurements, vibrations or noise.	Turbine Contractor Generator Contractor
Progressively bring the turbine generator up to rated speed using the governor. The turbine generator shall remain at each speed step until such time as the bearing temperatures have stabilised. If any of the turbine generator instrumentation reaches an alarm or trip condition, or exhibits unusual behaviour. At each speed step it shall be verified that the closing devices are functioning correctly: • Verify adjustment for operation of governing system timing at rated speed. • Verify adjustment and measuring accuracy of the speed monitoring systems. • Verify adjustment of the overspeed devices.	Turbine Contractor Generator Contractor Turbine Contractor Generator Contractor Generator Contractor
A bearing heat run at rated speed shall then be conducted. The heat run shall continue for one hour after the bearing temperatures have stabilised. The following parameters shall be recorded during these tests:	Generator Contractor assisted by Control System Installation Contractor

• Ambient temperature. • Bearing temperatures. • Bearing oil temperatures. • Unit speed	
At the end of the test the turbine generator shall be shut down by simulating an overspeed event to demonstrate that the emergency shutdown systems are operating correctly.	Control System Installation Contractor

8.12.2.3 Generator Excitation, Protection and Synchronising Tests

Following the successful completion of the heat run the unit shall be started and the following tests conducted:

Activity	Responsible Party
Excite the generator for the first time. Verify that all voltage measurements are being read correctly in the Unit control system and shall undertake excitation system tests as required by the IEC standard and the manufacturer.	Control System Installation Contractor Excitation System Contractor
Test the generator electrical protection as far as possible by reducing settings below the actual measured values and confirming that the protection relays operate correctly.	Control System Installation Contractor
With the generator circuit breaker racked out, test synchronising against a dead bus, and verify phase sequence and phase angle between the generator and bus VTs.	Control System Installation Contractor
With the generator racked in and the main power transformer MV open and other generator circuit breaker open, retest synchronising against a dead bus and verify phase sequence and phase angle between generator and bus VTs.	Control System Installation Contractor

8.12.2.4 Overspeed Test

Activity	Responsible Party
Test the overspeed devices by increasing the turbine speed under manual control.	Generator Contractor assisted by Turbine Contractor

8.12.3 Commissioning Tests

8.12.3.1 First Synchronisation

The Commissioning tests shall commence with a first synchronisation and loading of the turbine generator.

Activity	Responsible Party
Set the governor load limiter to no more than 10% of rated.	Turbine Contractor

The turbine generator shall initially be started, synchronised and loaded (to the 10% limit) using the Unit Control System automatic start controls in 'step by step' manual override mode.	Control System Installation Contractor Assisted by Turbine Contractor and Generator Contractor

The tests shall then be repeated in fully automatic mode.

8.12.3.2 Load Rejection Tests

The turbine generator shall be started, synchronised and the load shall be increased in steps to the maximum value.

Activity	Responsible Party
At each step, observations and measurements in steady state condition shall be repeated and the operating stability of the turbine shall be verified.	Control System Installation Contractor Assisted by Turbine Contractor and Generator Contractor
The turbine generator shall be subjected to load rejection tests at each of the following load steps: 25%, 50%, 75% and 100% of rated load. The load rejection should operate into the turbine ESD controls and a different initiating event should be used for each test.	Control System Installation Contractor Assisted by Turbine Contractor and Generator Contractor
Record the following parameters during these tests: • Penstock pressure. • Spiral case pressure. • Guide vane position. • Turbine generator speed. • Circuit breaker position. • Inlet valve position.	Control System Installation Contractor

8.12.3.3 Turbine Inlet Valve Tests

The turbine inlet valve shall be demonstrated to be capable of emergency closing against the full turbine flow.

The turbine generator shall be started, synchronised and the load shall be increased in steps to the maximum value.

Activity	Responsible Party
At each step, observations and measurements in steady state condition shall be repeated and the operating stability of the turbine shall be verified.	Control System Installation Contractor Assisted by Turbine Contractor and Generator Contractor
The turbine inlet valve shall be closed against flow at each of the following load steps: 25%, 50%, 75%, 100% of rated load and at overspeed.	Control System Installation Contractor Assisted by Turbine Contractor and Generator Contractor
Record the following parameters during these tests: • Penstock pressure. • Spiral case pressure. • Guide vane position.	Control System Installation Contractor

• Turbine generator speed. • Circuit breaker position. • Inlet valve position	

8.12.3.4 Generator Heat Run

Activity	Responsible Party
Undertake a generator heat run at rated output. The heat run shall continue for one hour after the winding, cooling system and bearing temperatures have stabilised.	Control System Installation Contractor Assisted by Turbine Contractor and Generator Contractor
Record the following parameters during these tests: • Ambient temperature. • Stator winding temperatures. • Cooling system temperatures. • Turbine discharge water temperature. • Bearing temperatures. • Bearing oil temperatures. • Generator load.	Control System Installation Contractor

8.12.3.5 Trial Operation

Following successful completion of the Commissioning Tests, a Test Run (Trial Operation) shall be performed as required to assure that the equipment has been installed and adjusted properly and that it will function safely and properly under continuous operation. The test run shall be performed in the automatic control mode, without any adjustments or corrections, under certain loads specified by the Employer. The duration of the Test Run shall be for a continuous period (no interruptions allowed) of 720 hours. If the Test Run is interrupted due to malfunction of equipment, the Test Run shall be performed over again.

8.13 Spare Parts

8.13.1 Specified Spare Parts

The Contractor shall provide the following spare parts:-

- Two RTD elements of each type used.
- Two bearing cooling water flow transmitters.
- Two vibration sensors of each type used.
- One partial discharge coupling capacitor.
- One complete set of brushes and brush holders, with necessary insulation, for each generator.

8.13.2 Optional Spare Parts

The Contractor shall furnish a priced list of recommended Optional additional spare parts. This shall include

- One set of refurbished bearing pads to replace any used from the Employers stores.

8.14 Generator Data

Provide the following data.

Generator		Purchaser's Requirements	Vendor's Response
Generator wedging system details			
Speed monitoring system details			
Vibration monitoring system details			
Partial discharge system details			
RTD details (for each type)			
Bearing oil level transmitter details			
Bearing cooling water flow transmitter details			
Cooler Data			
• Cooler dimensions (LxWxH)	mm	~ 1380 x 1516 x 240	
• Cooler weight	kg		
• Cooler nominal water flow	l/s	226	
• Cooler maximum water flow (one cooler out of service)	l/s	248	
• Cooler nominal air flow	m^3/s	4.625	
• Cooler maximum air flow (one cooler out of service)	m^3/s	6.17	
• Inlet water temperature	C	27.1	
• Discharge water temperature	C		
• Inlet air temperature	C	62.7	
• Discharge air temperature	C		
• Cooler capacity	kW	120	
• Cooler air/water surface area	m^2	> 96.7	
• Maximum cooler water pressure	Bar	5	
• Test pressure	Bar	10	
• Water pressure loss through coolers	Bar	0.6	
• Air pressure loss through coolers	kPa	2.5	

Air cooler cooling water isolating/balancing valve manufacturer, type and size	in	IMI TA, STAD, 2”	
Upper bearing cooling water isolating/balancing valve manufacturer, type and size	in	IMI TA, STAD, 2”	
Lower bearing cooling water isolating/balancing valve manufacturer, type and size	in	IMI TA, STAD, 1”	
Isolating/balancing tool		IMI TA TA-SCOPE	

Schedule 1 – Tender Forms

Tender Form 1 – Letter of Tender

Name of Contract: Wailoa Mid Life Refurbishment Project, Generator Rehabilitation Contract No. MRXXXX/2016

Tender To: Fiji Electricity Authority
2 Marlow St
Private Mail Bag
Suva
Republic of the Fiji Islands

1. This tender is made by _____
[insert full name and registered address of tenderer].
2. Capitalised terms used in this letter have the meaning given to them in the Instructions to tenderers dated [*insert date*] ("**Instructions**") unless otherwise defined.
3. Having examined and understood the Tender Documents relating to the Works (including the Instructions and all documents attached thereto, including but not limited to the Particular Conditions of Contract, the General Conditions of Contract, the Specification and the Employer's Drawings) we, the undersigned, hereby offer to design, execute, complete and remedy defects in the whole of the Works in conformity with the said documents for the sum of:
….....
....., ($.....),

Exclusive of VAT, WHT or such other sum as may be ascertained in accordance with the Contract.

4. This offer is made on the terms and conditions set out in this Tender and the Instructions.
5. We attach the following documents which form part of this tender:
   (a) Completed tender forms;
   (b) Technical description of the plant offered;
   (c) Maintenance contract proposal
   (d) Proposed P&IDs – as applicable;
   (e) Proposed programme;
   (f) Proposed key personnel;
   (g) Any supplementary information;
6. We agree to abide by this Tender for a period of 60 days after the Tender Closing Date and that this Tender it shall remain binding upon us and may be accepted by you at any time before the expiration of that period.
7. We confirm that you may rely upon all statements made by us in response to the Instructions or in subsequent correspondence, discussions or negotiations with you.
8. We certify that:
   (a) The entry into, and performance of the obligations under, the Contract by us will not violate any laws provided that you obtain all consents and authorisations you are required to obtain under the Contract;
   (b) We have corporate power to enter into and perform our obligations under the Contract and we have taken all necessary corporate action to authorise the entry into, and execution of, this offer and (if required) entry into, and execution of, the Contract;
   (c) The rates and prices in our offer have been arrived at independently, without consultation or agreement with any other tenderer; and
   (d) No attempt has been made, nor will be made, by us to influence any other tenderer to submit or not submit a tender or to alter the proposed content of that tenderer's tender.
9. We acknowledge that this tender, and any contract arising upon its acceptance, shall be governed by and construed in accordance with the laws of The Fiji Islands.
10. Unless and until a formal agreement is prepared and executed, this Letter of Tender, together with your written acceptance thereof, shall constitute a binding contract between us.

We understand that you are not bound to accept the lowest or any tender you may receive.

Dated this _____ day of _____ 2016

Signature _____ in the capacity of _____

duly authorised to sign Tenders for and on behalf of: _____

Witness _____

Address _____

Occupation _____

Tender Form 2 – Tender Price and Price Breakdown

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Section 1 Unit 1 Generator		
Basic design report		
Detailed design report		
Pre-dismantling tests and report		
Disassembly		
Stator inspection, cleaning and NDT (including assessment report)		
Manufacture and delivery of replacement wedging system		
Re-wedge stator		
Stator RTD supply		
Phase/Neutral terminal reversal		
Partial discharge system supply and installation		
Rotor pole inspection, testing and cleaning (including assessment report)		
Rotor stub shaft manufacture		
Slip rings, brush gear and field Connections		
Speed measuring system		
Bearing rehabilitation		
Manufacture and delivery of four generator air/water coolers		
Generator cooling system refurbishment		
Generator high pressure oil system refurbishment		
Generator jacking system refurbishment		
Generator instrumentation upgrade		
Central vibration monitoring server		
Vibration monitor and sensors		
Reassembly and testing		
Commissioning and Testing		
Spare Parts		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Hydraulic Oil		
O&M Manuals		
Completed Test Reports		
As Built Drawings		
Section 1 Sub-Total		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Section 2 Unit 3 Generator		
Pre-dismantling tests and report		
Disassembly		
Stator inspection and NDT, cleaning and NDT (including assessment report)		
Manufacture and delivery of replacement wedging system		
Re-wedge stator		
Stator RTD supply		
Phase/Neutral terminal reversal		
Partial discharge system supply and installation		
Rotor pole inspection, testing and cleaning (including assessment report)		
Rotor stub shaft manufacture		
Slip rings, brush gear and field Connections		
Speed measuring system		
Bearing rehabilitation		
Generator cooling system refurbishment		
Generator high pressure oil system refurbishment		
Generator jacking system refurbishment		
Generator instrumentation upgrade		
Vibration monitor and sensors		
Reassembly and testing		
Commissioning and Testing		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Spare Parts		
Hydraulic Oil		
O&M Manuals		
Completed Test Reports		
As Built Drawings		
Section 2 Sub-Total		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Section 3 Unit 2 Generator		
Pre-dismantling tests and report		
Disassembly		
Stator inspection and NDT, cleaning and NDT (including assessment report)Stator inspection and NDT		
Manufacture and delivery of replacement wedging system		
Re-wedge stator		
Stator RTD supply		
Phase/Neutral terminal reversal		
Partial discharge system supply and installation		
Rotor pole inspection, testing and cleaning (including assessment report)		
Rotor stub shaft manufacture		
Slip rings, brush gear and field Connections		
Speed measuring system		
Bearing rehabilitation		
Generator cooling system refurbishment		
Generator high pressure oil system refurbishment		
Generator jacking system refurbishment		
Generator instrumentation upgrade		
Vibration monitor and sensors		
Reassembly and testing		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Commissioning and Testing		
Spare Parts		
Hydraulic Oil		
O&M Manuals		
Completed Test Reports		
As Built Drawings		
Section 3 Sub-Total		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Section 4 Unit 4 Generator		
Pre-dismantling tests and report		
Disassembly		
Stator inspection and NDT, cleaning and NDT (including assessment report)Stator inspection and NDT		
Manufacture and delivery of replacement wedging system		
Re-wedge stator		
Stator RTD supply		
Phase/Neutral terminal reversal		
Partial discharge system supply and installation		
Rotor pole inspection, testing and cleaning (including assessment report)		
Rotor stub shaft manufacture		
Slip rings, brush gear and field Connections		
Speed measuring system		
Bearing rehabilitation		
Generator cooling system refurbishment		
Generator high pressure oil system refurbishment		
Generator jacking system refurbishment		
Generator instrumentation upgrade		
Vibration monitor and sensors		

Item	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Reassembly and testing		
Commissioning and Testing		
Spare Parts		
Hydraulic Oil		
O&M Manuals		
Completed Test Reports		
As Built Drawings		
Section 4 Sub-Total		

Tender Price Summary	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Section 1		
Section 2		
Section 3		
Section 4		
Provisional sum for Optional items and Additional Work		USD$200,000
Total Tendered Price		

Optional prices	Amount Fijian Dollars (FJD) excluding VAT	Amount Foreign Currency (Nominated by Tenderer)
Injection of a semi-conductor material to restore the stator winding stress gradient system (per stator)		
Rotor pole disassembly and re-insulation (per pole)		
Re-metalling one set of generator upper guide bearing pads		
Re-metalling one set of generator lower guide bearing pads		
Re-metalling one set of generator thrust bearing pads		
Total		

Signature	……
Name	……
Position	……
Company	……
	……
Address	……
	……
Date	……

Tender Form 3 – Proposed Key Personnel

Contract Manager:	.....
Lead Design Engineer:	.....
Site Works Manager:	.....
Site Works Supervisor:	.....
Site Works Safety Supervisor:	.....
Commissioning Engineer:	.....

Signature	.....
Name	.....
Position	.....
Company	.....
Address	.....
Date	.....

Tender Form 4 – Proposed Suppliers and Sub-Contractors

……

……

……

……

Signature	……
Name	……
Position	……
Company	…… ……
Address	…… ……
Date	……

Tender Form 5 – Schedule of Hourly Rates

Personnel	Basic Hourly Rate On Site (State Currency) ($/h excluding GST and WHT)
Contractor Manager:	.....
Lead Design Engineer:	.....
Design Engineer:	.....
Site Works Manager:	.....
Site Works Supervisor:	.....
Site Works Safety Supervisor:	.....
Fitter Welder:	.....
Fitter Trades Assistant:	.....
Electrician:	.....
Electrical Trades Assistant:	.....
Software Engineer/Programmer:	.....
Labourer:	.....

Basic hourly rates apply for the first ..... hours worked in any one day.

Overtime rates apply thereafter as follows:
Next ..... hours at ..... times basic rates.
Next ..... hours at ..... times basic rates.

Tender shall specify any special factors applicable to adjust the basic hourly rates for work on weekends and public holidays.
Weekend factor .....
Public holiday factor .....

Explanatory Notes
(a) The Tenderer shall complete the Schedule of Hourly Rates tender form to show the basic hourly rates applicable for any authorised extra work on the site.
(b) The Schedule will be used as a basis for evaluating tenders and as a basis for agreeing cost for any extra authorised work.
(c) The basic hourly rate shall include all overheads, profit, hand tools and allowances and shall represent the total cost to the Employer for personnel employed during normal working hours. The rates shall be exclusive of GST.
(d) The scheduled hourly rates shall be applicable throughout the course of the works.
(e) Time sheet records shall be supplied by the Contractor as a basis for agreeing costs for any extra work.

Signature ……
Name ……
Position ……
Company ……
……
Address ……
……

Date ……

Tender Form 6 – Percentage On-Costs

Item	Description	Percentage on Cost
1.	Equipment and materials supplied on cost plus basis (including transport).	.....
2.	Sub-contractors employed on cost plus basis.	.....
3.	Equipment hire.	.....
4.	Contractor's profit.	.....

Explanatory Notes

(a) The Tenderer shall complete the Percentage on Costs form to show the percentage on cost applicable for supplying extra equipment and materials, employing extra Sub-contractors on a cost plus basis and for arranging extra equipment hire.
(b) The percentage on costs shall allow for all costs incurred by and profits for the Contractor in arranging for the supply of any extra equipment and materials or hire of any extra equipment.
(c) The percentage on costs shall allow for all costs incurred by and profits for the Contractor in arranging and managing any extra Sub-contractors employed on the job.
(d) Invoices shall be supplied by the Contractor to substantiate any claim for costs associated with work performed on a cost plus basis.
(e) The percentage on costs and invoices will be used as a basis for agreeing costs associated with any variations to the contract.

Signature ……
Name ……
Position ……
Company ……
……
Address ……
……
Date ……

Tender Form 7 – Statement of Conformance

We have read and understood the Tender documentation for the generator rehabilitation contract, and confirm that:

Tick 1 Box as Applicable

☐ Our Tender is in full compliance with the requirements and we have no exceptions to note.

☐ Our Tender does not fully comply with the requirements. The following exceptions apply:

……
……
……
……
……
……
……
……

Signature ……

Name ……

Position ……

Company ……
……

Address ……
……

Date ……

Schedule 2 – Form of Contract Agreement

This Agreement is made this day of 2016

Between The Fiji Electricity Authority,
(Herein called the Employer)

And ,
(Herein called the Contractor)

Whereas

A. The Employer requires that certain Works be provided and executed by the Contractor set out in clause 2 below, the Works being more particularly defined in the Contract documents:
B. The Contractor has submitted a Tender to the Employer for the provision and execution of the Works by the Contractor for the sum of FJ$_____ plus FX$_____ (foreign Currency to be nominated at time of tender) (the Contract Price) and the Employer has accepted such Tender:
C. The Employer has appointed Mr Robin Spittle to be the Engineer for the purpose of the Works:

NOW THEREFORE the parties are agreed as follows:

1. In this Contract Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract hereinafter referred to.
2. The following documents shall be deemed to form and be read and construed as part of this Agreement:

   - Contract Agreement
   - The Letter of Acceptance
   - Preamble
   - The completed Tender Schedules
   - Notice to Tenderers (NTT)
   - Particular Conditions of Contract
   - General Conditions of Contract
   - Specifications (with Section 3 taking precedence over Section 4)
   - Letter of Tender
   - Contractor's Proposal
   - Instructions to Tenderers.

   Should there be any ambiguity or discrepancy between these documents the documents shall take precedence in the order of priority listed above.
3. In consideration of the payments to be made by the Employer to the Contractor in accordance with the Contract, the Contractor shall design, execute and complete the Works and remedy defects therein in conformity in all respects with the provisions of the Contract.

4. The Employer shall pay the Contractor in consideration of the design, execution and completion of the Works and the remedying of defects therein the Contract Price or such other sum as may come payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.
5. The parties have entered into this Agreement in accordance with their respective laws and statutes or constitutions on the date hereof by their fully authorised signatories.

Binding signature on behalf of the Employer Title: .....
..... Dated: .....

Binding signature on behalf of the Contractor Title: .....
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Appendix A Existing Generator Selected Drawings and Documents

SECTION 2

TIBB

CONTENTS.

Drawings.

The following drawings are included at the end of this section:

- Fig. 1 - Generator Construction.
- Fig. 2 - Core Plate.
- Fig. 3 - Stator Core.
- Fig. 4 - Slot Section with Winding.
- Fig. 5 - Generator Pole - Plan View.
- Fig. 6 - Generator Pole - Cross Section.
- Fig. 7 - Ventilation Layout.

SECTION 2

2. Description

2.1. Main Components - see Fig. 1 and Drg. UW 002185, Sec. 6

The construction of the generator with a list of major components is shown on Fig. 1 included at the end of this section. As will be seen, the complete generator is supported on a heavily reinforced concrete plinth to which are bolted the stator frame (1) and the lower bearing (8).

The combined weight of the generator and turbine rotors is supported by the combined thrust and guide bearing (7) mounted in the upper bracket (6) supported on the top of the stator frame. The stator frame also resists the counter torque resulting from normal operation and the worst case short circuit which can be up to 20 times higher.

The lower bracket (5) supports the lower guide bearing (8) and in addition is fitted with jacks which bear on the underside of the flywheel (4) for use for maintenance purposes only.

The auxiliary (upper) rotor (10) carries the rotors of the main (11) and pilot (12) exciters. Also mounted on this shaft are the slip rings and the tooth disk for the main speed sensing system. The stators for the main and pilot exciters are supported in the main exciter (13) and pilot exciter (14) housings supported on top of the upper bracket.

On top of the generator are mounted the PMG with tacho generator (15) which serve the turbine governor, and these devices are described in Volume 2, Sections 8 & 9.

2. Description.

2.1. Main Components (cont'd).

Not shown on Fig.1, since they are dealt with in detail in Volume 3(b) (this book) are:-

- The Cooling Water (CW) System - Sections 1-3.
- The High Pressure Oil (HPO) System - Sections 4-6.
- The Rotor Jacking System - Sections 7-9.

2. Description.

2.2. Stator.

2.2.1. Stator Frame - see Fig. 1 and Drg. UW002185, Sec.6.

One piece welded construction from steel plate heavily ribbed and stiffened (note: the stator frames for Units 1 & 2 were originally planned for manufacture and delivery in halves but were in fact completed in the factory and delivered to site as one piece).

The bottom flanges at the stator frame is bolted to four foundation feet which are qrouted to the concrete plinth and additionally secured by through bolts. Dovetail bars are welded to the stator frame to assemble the stator core laminations and the ends of these bars have a screw thread for the pressure plate locking nut (Fig.3).

2.2.2. Stator Core - see Figs. 2 & 3 and Drg. UW103548, Sec.6.

The stator core is made of 17 overlapped lamination sets, each one separated by a 10mm spacer, giving 16 cooling channels in the active core parts.

Each set consists of low loss, 0.5mm thick laminations arranged staggered around the periphery. The laminations are coated on both sides with an insulating varnish capable of withstanding high temperature. Laminations are punched from a material with a loss of 1.7 Watt/Kg.

The laminations are positioned by dove-tail slots on the periphery. During the stacking process, the laminations are pressed from time to time to achieve a uniform density over the whole core length.

Strong press-plates, one at each end of the core, are pressed by means of through bolts (dove-tail bars) and compress the laminations via fingers acting on the slot teeth, the press-plate nuts being tightened to 90 Kg.m torque.

The lamination core is pressed at 300 tonnes.

2. Description

2.2. Stator (cont'd)

2.2.2. Stator Core (cont'd)

The main dimensions of the core are:
height = 1,300 mm x bore = 2000 mm x outside diameter = 2,700 mm.

Number of slots: 108

Having relative low induction losses in the core and good ventilation, no means for monitoring temperature in the laminated core are either necessary or provided.

2. Description.

2.2. Stator (cont'd).

2.2.3. Stator Winding - see Fig. 4.

See also Drgs. UW002035, UW002040 - Sec. 6, UW202782 - Sec. 7. The stator winding is a double layer coil winding with two active sides per slot. 108 coils are housed in 108 slots and each coil is formed by 6 series connected turns and each turn (2) consist of 6 parallel connected insulated strands (1). The coils are connected in 4 parallel circuits in each of 3 star connected phases forming an 8 pole winding.

The coils are inserted in the open slots of the laminated core and fixed by wedges (4) made of synthetic glass epoxy. The main coil insulation (6) is of continuous tape of woven glass fibre and fine grade mica treated according to the Brown Boveri "Micadur" process.

The coils are impregnated under vacum with a synthetic resin and pressed with special pressing tools and cured in an oven. After forming and pressing, the coil insulation is given a corona protection layer (5). The coil ends have also been provided with suitable anti-corona protection.

The winding overhangs are braced by interwoven resin impregnated glass fibre tapes.

The insulation method used has been developed by Brown Boveri and produces a homogeneous insulation free from air inclusions and characterized by low dielectric losses and high thermal stability. The insulation materials used meet the requirements of Class F according to IEC, NEMA and ASA Standards.

The temperature of the stator winding is monitored with the aid of six resistance thermometers type PT 100 uniformly distributed over the periphery in the coil center all mounted between the upper and lower coil, stator winding resistance at $75^{o}C$, R = 0.0131 Ohm / phase.

2. Description.

2.2. Stator (cont'd).

2.2.4. Stator Connections.

See also drgs. UW 002185 and UW 002035, Section 6.

Stator winding tails (UW 002035) are brought out and fixed by bolted clamp connections to insulated copper bars fixed to plates on the upper bracket by clamps fabricated from insulating material thus forming the stator line and neutral connections "U" "V" "W" and "X" "Y" "Z", respectively.

The bolted clamp joints between the tails and the stator connections were putty filled, taped and varnished after erection.

The electrical connections to the generator line and neutral cubicles are bolted-on, braided, flexible copper straps uninsulated, but shielded in the generating housing air casing against accidental contact by an expanded metal duct.

2. Description

2.3. Rotor - see Drg. UW 103.713, Section 6

The rotor proper consists of the following main parts:

- 1 lower/DE shaft with flywheel hub)
- 1 central body) comprising the rotor proper
- 1 upper/NDE shaft)

mounted on which are:

- 1 auxiliary shaft
- 1 flywheel
- 8 generator poles
- 2 generator fans
- 1 thrust block with runner, etc. - see 2.4.1.

and in addition, mounted to the main

and in addition, mounted on the main parts are:

- coupling flange to turbine - see Vol. 2, Sec. 1.10
- bearing seat for lower guide bearing - see 2.4.2.
- slip rings, associated brushes and leads - 2.5.1.
- fans for slip ring and exciter enclosure
- main ac exciter poles
- permanent magnet generator (pmg) poles
- coupling to turbine governor pmg & tacho generator - see Vol. 2, Sec 8 & 9
- toothed wheel for speed sensing

2. Description

2.3. Rotor (cont'd)

2.3.1. Drive-end (DE) Shaft

The DE shaft is fixed to the central body with 8 thermally stretched bolts. Machined on this shaft are the generator-turbine coupling flange, the lower guide bearing seat, and fitted on the shaft is the seat for the flywheel hub.

2.3.2. Central Body

The central body is a hollow forged spool. This is provided with tapped holes for coupling to the two shaft ends and T-shaped slots for mounting the poles.

2.3.3. Non-drive End (NDE) Shaft

The NDE shaft is fixed to the central body with 8 thermally stretched bolts. Machined on this shaft are the seats for the thrust collar and associated half-rings and the auxiliary shaft. The NDE shaft has a central bore for the connections from the slip rings on the auxiliary shaft (see Drg. UW 103.722, Sec. 6) to the rotor winding and for the turbine runner hoist cable.

2. Description.

2.3. Rotor (cont'd).

2.3.4. Auxiliary Shaft.

The auxiliary shaft is provided with a keyed sleeve connection to the NDE shaft, locked by half rings, above the thrust collar seat and on it are mounted, in ascending order:-

- the main rotor slip rings.
- the exciter slip rings.
- the main exciter poles.
- the main & auxiliary exciter compartment fan.
- the permanent magnet generator poles (P.M.G.).
- the coupling for the Governor P.M.G. with tacho generator and toothed wheel for speed sensing.

The central bore provides passage for the turbine runner hoist cable.

2. Description

2.3. Rotor (cont'd)

2.3.5. Flywheel

The flywheel is provided for:

- maintaining a stable frequency in spite of load variations
- limiting the runaway speed in case of a sudden load rejection

The flywheel effect (WD^2) of all the rotating parts is 111 tm^2.

The cast steel flywheel hub is shrunk on to the DE shaft and the forged steel flywheel is, in turn, shrunk on to the hub.

The outside diameter of the flywheel is greater than the stator bore so it must be removed before the rotor can be withdrawn. The OD of the hub (I.D. of flywheel) is smaller than the stator bore so the hub remains on the rotor shaft. Assembly and dismantling of the flywheel and hub are described in Section 4.

2. Description

2.3. Rotor (cont'd)

2.3.6. Generator Poles - see Drg. 103 631, Sec. 6.

Refer also Figs. 5 & 6.

The pole cores are made of steel laminations, Fig. 5 (1), punched from 2mm thick steel sheet. Two steel pieces* (12) mounted at each pole end, act as pressure plates. After packing the laminations, each pole is pressed at 470t and tied with 4 tension rods (3) & (4) inside the pole body. * Also see Figure 6.

The pole shoe is shaped to achieve the best voltage wave form and is provided with 10 axial bores to house the damper winding copper bars (5), which are brazed to the short-circuit rings (6) at each end.

The pole coils (7) are formed from flat copper strip, wound on edge. Each coil consists of 43 turns.

Each third turn, called a ventilation turn, has a larger surface area brought out to improve the cooling effect.

The turns are insulated from each other with "Nomex" inside the coils while insulation against pole shoe and pole cores is with "Vetresit" frames and "Nomex" plates (11). The coils are fixed laterally by non-magnetic metallic supports (9), arranged between the pole shoe edge and a bottom metal plate (10) solidly connected to the pole core.

Each pole is fitted with 2 tang-rails which slide into corresponding slot in the rotor body. At the lower end of one slot/pole is a stop which prevents the pole from dropping out - it is held in by gravity.

2. Description

2.3. Rotor (cont'd)

2.3.6. Generator Poles (cont'd)

Springs (8) press the coils against the pole shoe, preventing any movement of the coils in the poles in case of a slight compression of the coil radially due to centrifugal forces. The coils are electrically connected to the slip rings via the shaft bore. The rotor winding resistance is 0.111 Ohm at 75^{o}C and the impedance 22.7 Ohm at 50 Hz.

2. Description

2.3. Rotor (cont'd)

2.3.7. Generator Fans - see also Drg. UW 103.719, Sec. 6

The fans for the circulation of the cooling air (see 2.5.2.) located on the upper and lower ends of the central body (2).

The cast aluminium fan blades are supported in rings fabricated from weld steel plate bolted to the central body. Each complete fan has 35 blades set in the workshop and locked in position by a screw entering the blade tang - see Drg. UW 103.719.

The angle between the axis of blades and the horizontal plane is 11° and the fans are designed for one direction of operation only.

2. Subparagraph 2.3.8. is deleted.

This page is included for continuity.

2. Description.

2.4. Bearings - see Fig.1 and Drg. UW 002185, Section 6.

The generator is provided with:

- an upper combined thrust and guide bearing supporting the weight of the combined generator and turbine rotors.
- a lower guide bearing.

2.4.1. Upper Combined Thrust and Guide Bearing.

Upper Bracket Assembly - see Drg. UW 103636, Section 6.

The upper bearing is located in the upper bracket which consists of a large ring with 4 arms transferring to the stator frame (Drg. UW 103636, Section 6) all the loads due to the weight of the rotating parts.

The bracket is equipped with an integral oil tank on which is mounted the combined thrust and guide bearing proper and the associated oil cooler.

Pressurised labyrinth seals are provided to prevent the escape of oil vapour.

Connection are provided for:

- oil filling (via Item 26, UW 103636) and draining (latter with valve, Item 23, UW 103636).
- cooler cooling water connections.
- instrumentation, i.e., temperature detectors and oil level indicator/switch, etc.
- for HP oil supply to the thrust bearing pads.

The oil fill is 1,070 litres (nominal).
Details of the oil coolers (oil/water heat exchangers) are given on Drg. UW 103725 (Section 7) and the associated cooling water system, for dissipating the heat transferred from the bearing oil, is described in Volume 3(b).

2. Description.

2.4. Bearings (cont'd).

2.4.1. Upper Combined Thrust and Guide Bearing.

Thrust & Guide Bearing Assembly - see Drg. UW 103392 Section 6.

Thrust Bearing.

The thrust bearing proper consists of 8 circularly arranged tilting pads (4) lined with white metal mounted on individual pivotted pad supports (7) which in turn are mounted on the support ring (8). The support ring (8) is in turn intermittently supported on blocks with shims (17) and (18), which latter are adjustable to promote uniform load distribution, and are insulated (11) from the upper bracket and hence from earth.

The tilting pads (4) support the combined turbine and generator rotor shafts via the runner (2) and thrust collar (1) which latter is shrunk on the generator shaft with a low interference fit (375mm Ø M6/h5) and retained by trapped half rings (13). The half rings transmit the weight of the rotating parts through the thrust collar, runner and thrust bearing to the upper bracket.

The thrust bearing proper is immersed in oil and functions at all except low speeds on hydrodynamic principles (Michel/Kingsbury type). The HP oil system described in Vol.3(b) provides high pressure oil directly to the tilting pad faces for hydrostatic lubrication at low speeds.

The HPO System starts before the turbine inlets are opened and stops at 50% speed on startup. On shutdown the system starts at 50% speed and stops at a pre-set interval after shaft speed can no longer be sensed.

2. Description.

2.4. Bearings (cont'd).

2.4.1. Upper Combined Thrust and Guide Bearing.

Thrust & Guide Bearing Assembly - see Drg. UW 103392 Section 6.

Should the HPO System fail during shutdown, an emergency shutdown protection sequence will be initiated and the brake jet will be applied to shorten the shutdown period. Under these circumstances the bearing will maintain sufficient lubrication for the shorter period.

As shown, the thrust bearing has an inherent self-circulation oil system to the oil cooler induced by the rotation of the thrust runner (2). The internal cylinder, item (27), is an oil baffle to prevent oil overflowing onto the shaft and down onto the generator rotor.

Guide Bearing.

This bearing is of the self lubricated type consisting of white metal lined segmental guide pads (16) located in guides (20) and supported by the upper ring (15) and immersed in the oil. The guide bearing pads (16) have a nominal 0.25mm radial clearance to the journal face on the thrust collar runner (4). The journal face is 860mm diameter and the guide pads are machined to 864mm diameter after white metalling, leaving a white metal thickness of 3mm.

The guide bearing pads (16) are insulated from earth by the insulation pads (25) fitted between the pads (16) and guides (20), etc.

2. Description

2.4. Bearings (cont'd)

2.4.2. Lower Guide Bearing - see Drg. UW 103.738, Sec. 6

Lower Bracket Assembly

The lower guide bearing is located in the lower bracket/cross which is also equipped with jacks for rotor lifting during assembly and dismantling. The 4 arms of the lower bracket are bolted to and embedded into concrete foundation.

The lower bracket incorporates an integral housing for the lower guide bearing beneath which is provided an oil tank (11) with oil cooler (15) and baffle (12) which enters the recess on the shaft to above the maximum oil level.

Labyrinth seals are provided to prevent the escape of oil vapours (14) and (21).

Connections are provided for:

- oil filling and draining (latter with valve)
- cooler cooling water connections
- vents with valves (2) to the cooler water space
- instrumentation, i.e., temperature detectors and oil level indicator/switch

The oil fill is 300 liters (nominal).

Details of the oil coolers (oil/water heat exchangers) are given on Drg. UW 203049, Section 7, and the associated cooling water system, for dissipating the heat transferred from the bearing oil, is described in Volume 3(b).

2. Description

2.4. Bearings (cont'd)

2.4.2. Lower Guide Bearing (cont'd)

Guide Bearing

This bearing is of the self-lubricated type consisting of 4 white metal lined segmental guide pads (2) and (3) supported on wedges (4) and (5) from posts integral with the lower bracket.

The guide pads (2) and (3) are immersed in oil and circulation of oil to the cooler is achieved through the pumping effect of holes provided in the shaft journal (Note: refer MMP Drg. No. 27:08 S089 to 92, Section 6, for details of holes plugged during commissioning.)

The guide pads are machined to 662 mm diamter after white metalling, leaving a white metal thickness of 3 mm. The radial clearance to the shaft journal of 660 mm diameter is 0.25 mm nominal.

2. Description.

2.5. System Components.

Incorporated in the generator are components for supporting systems necessary for the correct functioning generation plant; as follows:-

2.5.1. Excitation System.
2.5.2. Sliprings, Brushes and Leads.
2.5.3. Generator Air Cooling System.
2.5.4. Generator Housing.
2.5.5. Systems for Generator Operation Monitoring and Protection.
2.5.6. High Pressure Oil System.
2.5.7. Rotor Jacking System.
2.5.8. Exciter Housing Heaters.
2.5.9. Generator Housing Heaters.

2. Description.

2.5. System Components (cont'd).

2.5.1. Excitation System - refer also Volume 4.

The excitation system for the generator comprises the following main components:

a) the generator permanent magnet generator (i.e., Generator PMG), the stator of which feeds:

a remotely mounted Thyristor bridge rectifier, controlled by a fast response automatic voltage regulator (AVR), which in turn feeds and controls the excitation to:

the main a.c. exciter rotor winding via the exciter slip rings.

b) the main a.c. exciter stator which is connected to:

a diode bridge AC/DC rectifier system housed in a force ventilated floor standing cubicle which feeds:

the rotor field winding on the generator poles via:

the generator slip rings and the slip ring leads.

The generator mounted components comprise:

- the Generator PMG.
- the Main A.C. exciter.
- the slip ring assemblies, brush boxes, brushes and leads.

2. Description.

2.5. System Components (cont'd).

2.5.1. Excitation System (cont'd).

Generator PMG - see Drg. UW 002185, Section 6. Conprises a three-phase, star-connected machine with three segregated terminals for connection to the thyristor rectifier system.

The frame, housing the stator core, is mounted above the housing of the main a.c. exciter.

The laminated stator core, 580 mm bore, 135 mm high, is formed by one-piece punched laminations, pressed by 2 pressure plates and fitted with a two-layer coil winding.

The rotor consists of a circular steel core shrunk onto the auxiliary shaft fitted with 8 permanently magnetized poles.

Technical data of the PMG:

Type	WPE 58-13-8R20
Rated power	7 kVA
Voltage	190 $\pm$ 10% V
Current	21 A
p.f.	0.6
Speed	750 rpm
Frequency	50 Hz
Stator weight	268 kg
Stator/rotor radial gap	2 mm

2. Description

2.5. System Components (cont'd)

2.5.1. Excitation System (cont'd)

Main A/C Exciter - see Drg. UW 002.185, Sec. 6

Comprises a three-phase generator type WA 75/35/8, star connected with three segregated terminals for connection to the AC/DC rectifier.

The exciter stator consists of a conical shaped cover supported by the upper bracket and housing the laminated core, formed by 0.5 mm, 1.7 W/kg plates, stacked in and fixed to a welded frame.

The laminated core, height 350 mm, bore 750 mm, has 66 slots, fitted with a double layer coil winding.

Stator winding resistance at 15°C: 0.00153 Ohm/phase.

The 8 poles forming the rotor, are each directly fastened with two bolts to the auxiliary shaft.

The 45 active turns, forming the rotor winding on each pole, are made of flat copper strip, wound on edge and insulated with 0.2 mm Nomex.

Rotor winding resistance at 15°C: 0.207 Ohm.

A double fan, mounted between the main exciter and the P.M.Generator ventilates both machines. The cooling air taken from the exterior is drawn through filters and, after cooling the exciters, is exhausted.

2. Description

2.5. System Components (cont'd)

2.5.1. Excitation System (cont'd)

Main A/C Exciter (cont'd)

Technical data for the a.c. exciter:

Rated power	143 kVA
Voltage	110 V
Current	751 A
p.f.	0.94
Rated speed	750 rpm
Frequency voltage	50 Hz
Excitation voltage	32 V
Excitation current	51 A
Stator/rotor radial gap	5 mm

2. Description.

2.5. System Components (cont'd).

2.5.2. Slip Rings, Brushes and Leads.

Slip Rings - see Drg. UW 103787, Section 6.

Two pairs of slip rings, together with the brushes distributed around the complete circumference, provide the change-over from the stationary to the rotating sections of the excitation circuits for the generator and main exciter rotor windings.

The individual rings are a shrink fit over insulation applied to the auxiliary shaft.

The exciter slip ring pair is situated above the generator pair and are narrower. Above them again is a 5th ring which acts as a closing (or seal) ring for air circuit integrity and has no electrical function.

Filtered air is drawn into the slip ring enclosure and removes the heat generated by the slip rings by exhausting to the exterior.

Carbon Brushes - see 4.3.4. for Maintenance/Adjustment and Drgs. UW 103793, UW 002185 in Section 6.

Drg. UW 103793 shows the detailed arrangement of brushes and collecting arcs for the generator rotor circuit while the details for the main exciter are similar as noted below.

The main generator slip rings are each fitted with 10 carbon brushes type EG 34D, 32mm x 32mm sq. section x 65mm long. An additional 2 brushes of the same size, one for each ring, are provided for monitoring the rotor temperature.

2. Description.

2.5. System Components (cont'd).

2.5.2. Slip Rings, Brushes and Leads (cont'd).

Carbon Brushes (cont'd)

The exciter slip rings are each equipped with 4 brushes type EG 34D, 32mm x 20mm section x 65mm long.

The carbon brushes bearing on the slip rings are electrically connected to the copper arcs to which the slip ring leads are attached. The copper arcs are fixed to the slip ring enclosure by insulated supports.

Leads - see Drg. UW 103722, UW 103713 and UW 103787 Section 6.

The connections between the generator slip rings and the rotor winding are made inside the NDE shaft - 2.3.3. - as Drg. UW 003722. The connections between the main exciter slip rings and the main exciter rotor winding are made external to the shaft as shown on Drg. UW 103713 and UW 103787.

2. Description.

2.5. System Components (cont'd).

2.5.3. Generator Air Cooling System - see Fig.3 & 7 and Drg. UW 002185, Section 6.

The generator stator and rotor windings are cooled by a closed air circulation system as Fig.3 & 7 within the generator cover (2) rejecting heat losses to the air/water heat exchangers (1) fitted on the exterior of the stator frame.

The cooling water system described in Vol. 3(b) rejects in turn the heat losses to the turbine tailrace via water/water heat exchangers.

The generator mounted components comprise:

- the generator fans (4) on the rotor (see 2.3.7.) and associated baffles on the stator.
- the air/water heat exchangers on the stator frame - drg. UW 302516, Section 6.
- the air casing as part of the generator housing 2.5.3.
- the cooling water pipework valves and fittings within the generator housing as detailed in Volume 3(b), Sections 1 - 3.

2. Description.

2.5. System Components (cont'd).

2.5.4. Generator Housing - see Drg. UW 002185, Section 6.

The generator housing comprises a painted sheet steel structure of bolted together frame sections and provided with:

- acces door.
- access ladder and handrails for upper working platform.
- anticondensation heaters, 4 off x 2, 500W, 415V single phase.
- internal lights and switch.
- cutout with cover for incoming and return cooling water bussmains.
- Junction Box JD (on Stator Frame).

Mounted on the outside of the casing on a frame is the Generator Line and Neutral Cubicle - refer Volume 6(b), Drg. UQR 000214 which is connected to the stator winding via flexible copper leads shrouded in the generator interior air space by an expanded metal duct.

Also within the Generator Line & Neutral Cubicle, is a separate Low Voltage Component; see 2.5.5(p).

2. Description.

2.5. System Components (cont'd).

2.5.5. Systems for Generator Operation Monitoring and Protection.

"Ancillary Devices included in the generator for monitoring its operation are listed here-under. The physical locations of these devices are shown on the drawings, Sections 6 & 7, and on the illustration, Fig.1, Section 8, while Sections 8 & 9 provide detailed listings and data sheets, respectively, for the devices. The function of these devices are described in the following Section 3.

a) Bearing metal and oil temperature sensors for instruments and for alarm/protection temp. switches.

b) Bearing CW flow indicators with control/alarm/ protection flow switches.

c) Bearing oil level gauges, with alarm level switches.

d) HP lube oil pressure switches for control/alarm/ protection.

e) Generator winding temperature sensors for instruments.

f) Generator hot air temperature sensors for instruments and for alarm/protection temp. switches.

g) Generator cold air temperature sensors for instruments.

h) Generator air CW flow indicators with control/ alarm flow switches.

j) Rotor winding temperature measuring circuit for instrument and for alarm/protection.

k) Rotor Jacks position monitoring limit switches for control/alarm/protection.

m) Exciter winding temperature sensors for instruments.

n) Exciter hot air temperature sensors for instruments and for alarm/protection.

p) Speed sensing equipment for control/protection.

2. Description

2.5. System Components (cont'd)

2.5.6 HP Oil System

As described in Vol. 3(b), the HP oil system provides pressure oil for hydrostatic lubrication at low speeds (see also 2.4.1.), (Vol. 3(b), Sections 4-6).

Supply and return pipes connect the generator upper bearing oil reservoir to the HP oil system while within the oil reservoir (Drg. UW 103.392, Sec. 6) a ring main connected to the supply feeds the individual thrust pads (UW203205, Sec. 6),

2.5.7 Jacking System

Provided for overhaul/rebuilding purposes only and described in Vol. 3(b), Sections 7 — 9.

The jacks are mounted on the lower bearing bracket - Drg. UW 103.738, Sec. 6.

2. Description.

2.5. System Components (cont'd).

2.5.8. Exciter Housing Heater.

The exciter housing is fitted with a single 350 Watt, 240V AC heater (Item 7, Section 8) controlled by a thermostat (Item 6, Section 8).

These are connected to the same circuit as the housing lighting through Junction Box JC. For the circuit diagram refer UW 390109, Section 6.

2.5.9. Generator Housing Heaters.

The generator housing is fitted with 4 x 2500 Watt, 415V AC heaters (Item 25, Section 8) controlled by a thermostat (Item 36, Section 8).

These heaters are mounted equi-spaced between stator feet on the plinth.

These are connected to their own control circuit housed in Junction Box JE. For the circuit diagram of this system refer to Drg. UW 302766 in Section 6.

FEA-WAILOA 1-4

GENERATORS

Illustration for Instruction Book Vol 3a Section 2

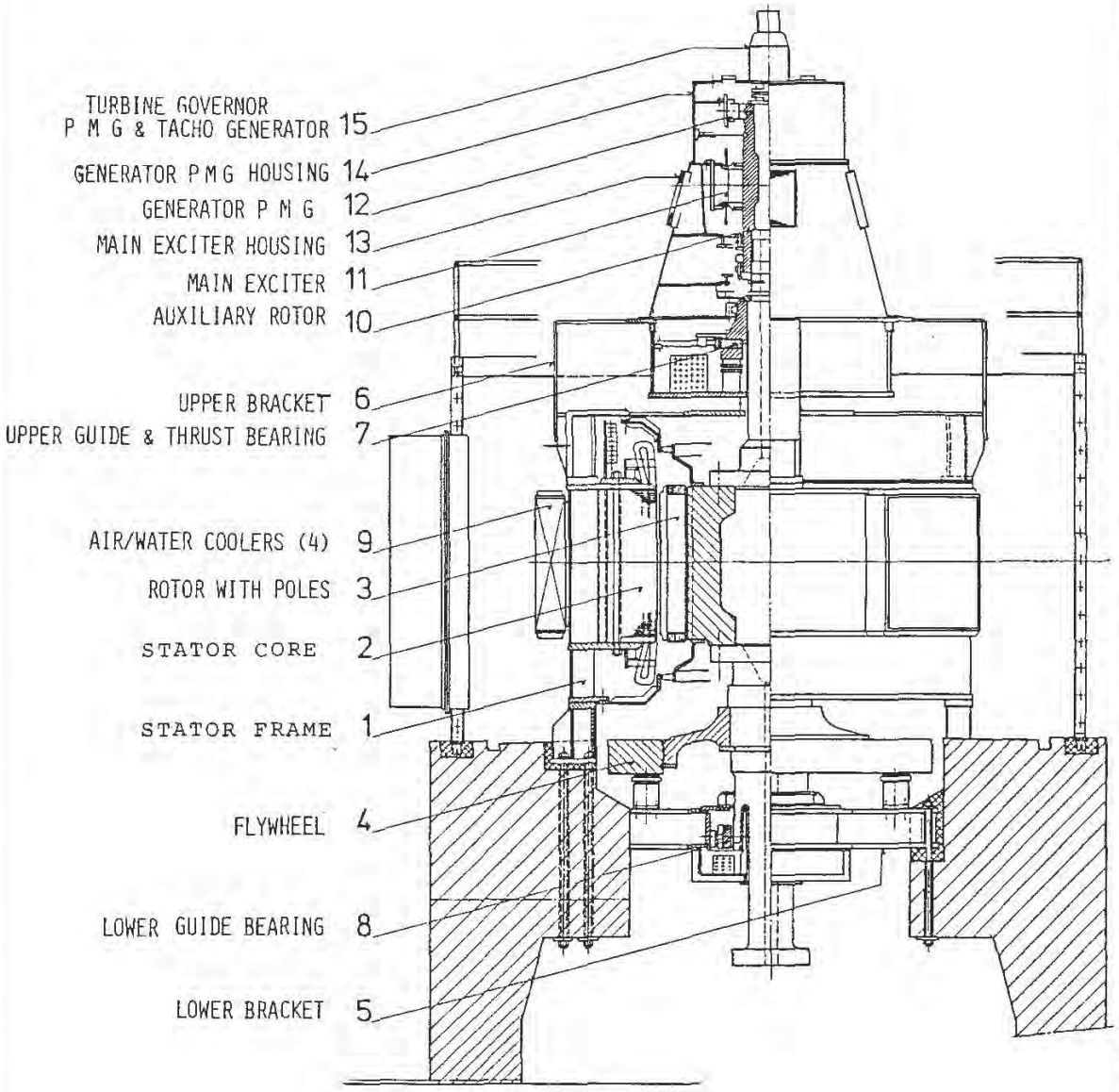
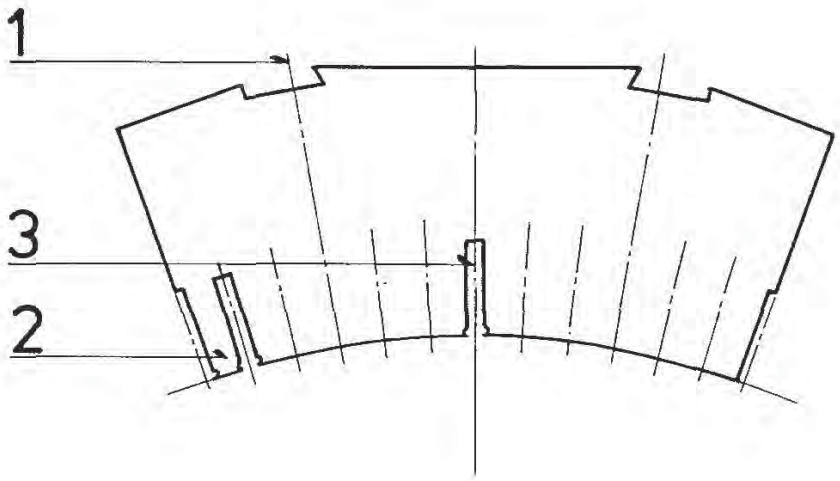


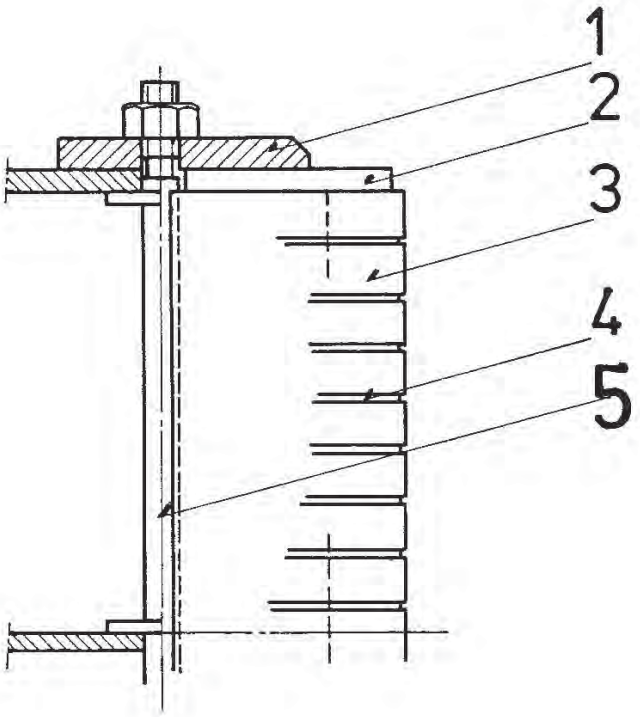
FIG No 1



ONE CORE PLATE

1 SLOT FOR LOCATING INTO STATOR FRAME
2 TOOTH
3 WINDING SLOT

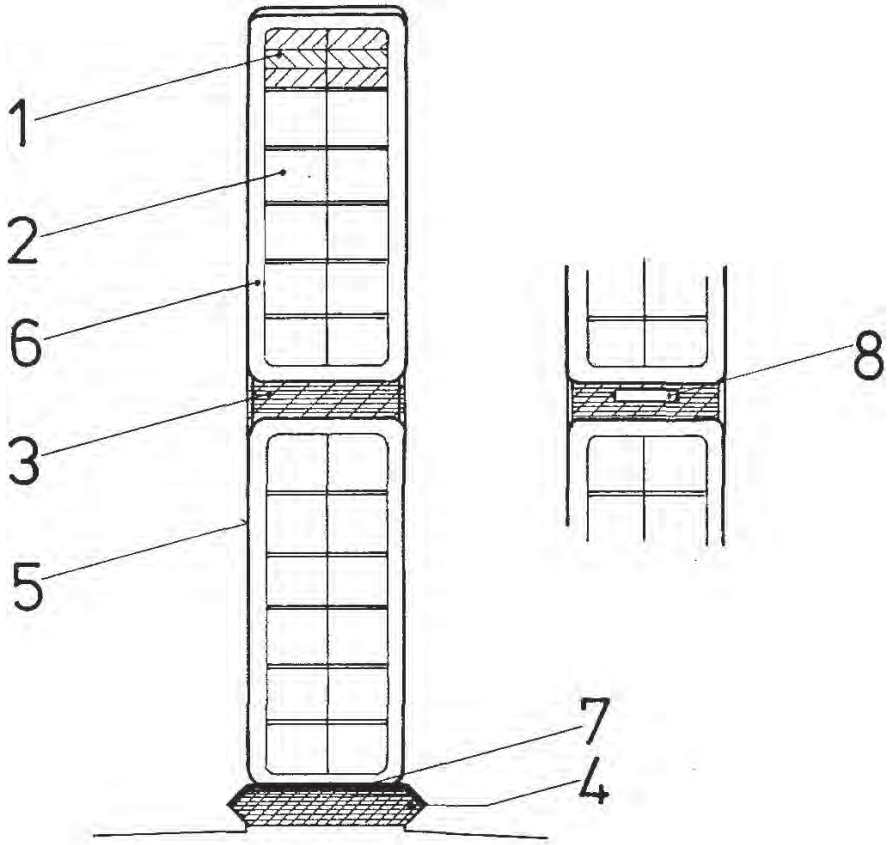
FIG No 2



STATOR CORE

1 PRESS-PLATE
2 PRESS-FINGERS
3 LAMINATION SET
4 VENTILATION DUCT / COOLING CHANNEL (10 MM)
5 DOVETAIL BARS

FIG No 3

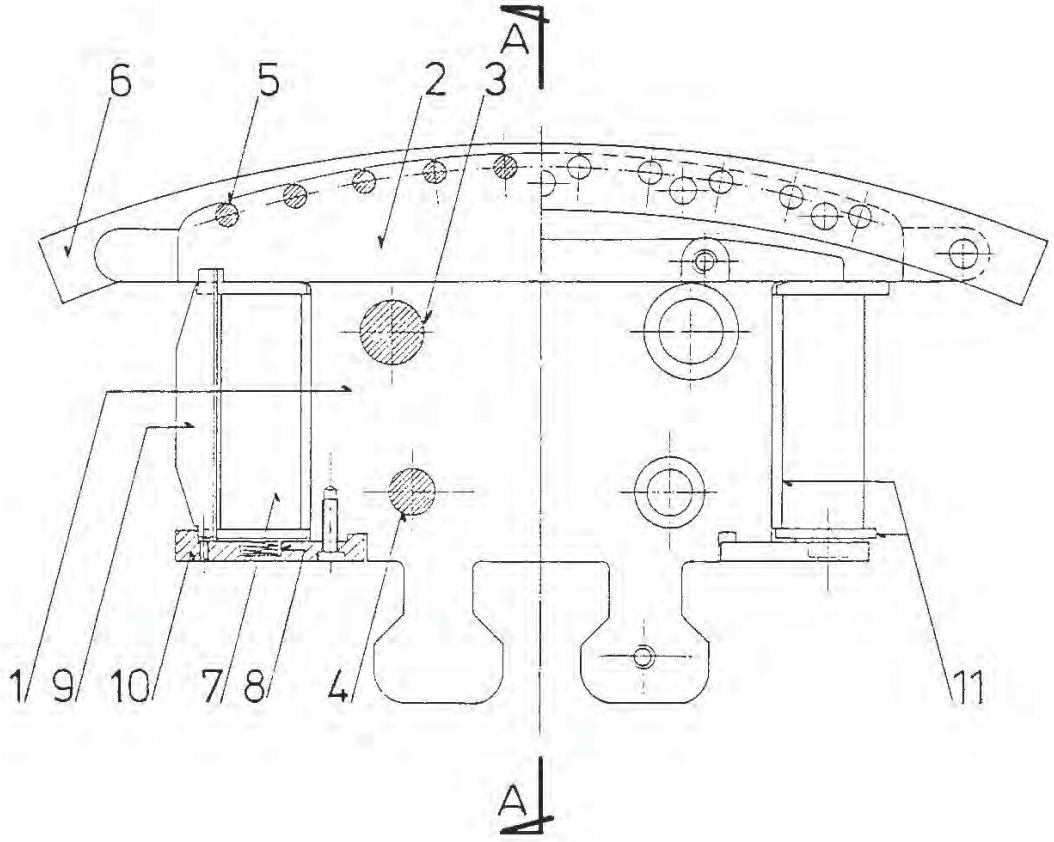


SLOT SECTION WITH WINDING

1 INSULATED STRAND
2 TURN
3 INSULATION DISTANCE PIECE
4 SLOT WEDGE
5 CORONA PROTECTION
6 MAIN INSULATION
7 WEGDE INSERTION
8 WINDING TEMPERATURE PROBE POCKET (IN 6 SLOTS ONLY)

SEE DRG. UW002040 FOR DETAILS OF COMPLETE INSULATION SYSTEM.

FIG No 4

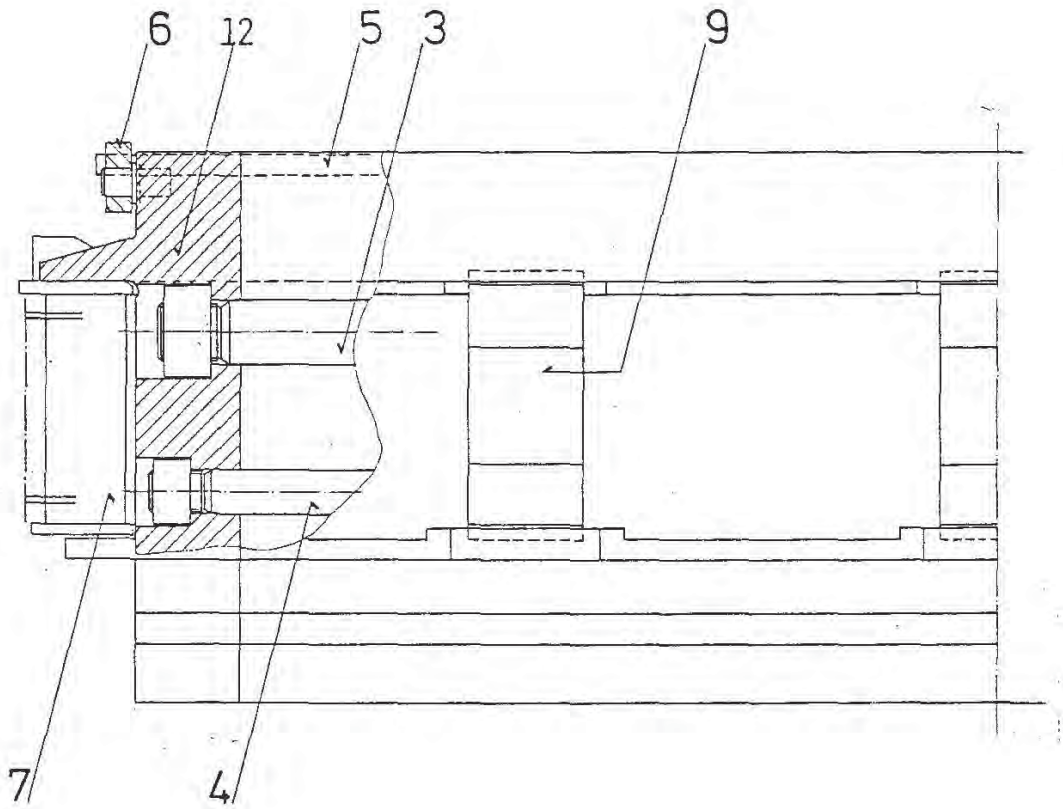


GENERATOR POLE - PLAN VIEW

1 POLE CORE LAMINATIONS
2 POLE SHOE
3 TENSION ROD
4 TENSION ROD
5 DAMPER WINDING COPPER BAR
6 DAMPER WINDING COPPER BAR CONNECTION
7 POLE COILS
8 COMPRESSION SPRING
9 COIL METALLIC SUPPORT
10 BOTTOM METALLIC PLATE
11 INSULATION

FIG No 5

FEA-WAILOA 1-4
GENERATORS
Illustration for Instruction Book Vol 3a Section 2



GENERATOR POLE - CROSS SECTION AA FIG. 5

3-4	TENSION RODS
5	DAMPER WINDING COPPER BAR
6	DAMPER WINDING COPPER BAR CONNECTION
7	POLE COIL
9	COIL METALLIC SUPPORT
12	PRESSURE PLATE

FIG No 6

FEA-WAILOA 1-4
GENERATORS
Illustration for Instruction Book Vol 3a Section 2

VENTILATION LAYOUT

1 AIR/WATER HEAT EXCHANGER
2 GENERATOR COVER
3 COOLING AIR FLOW

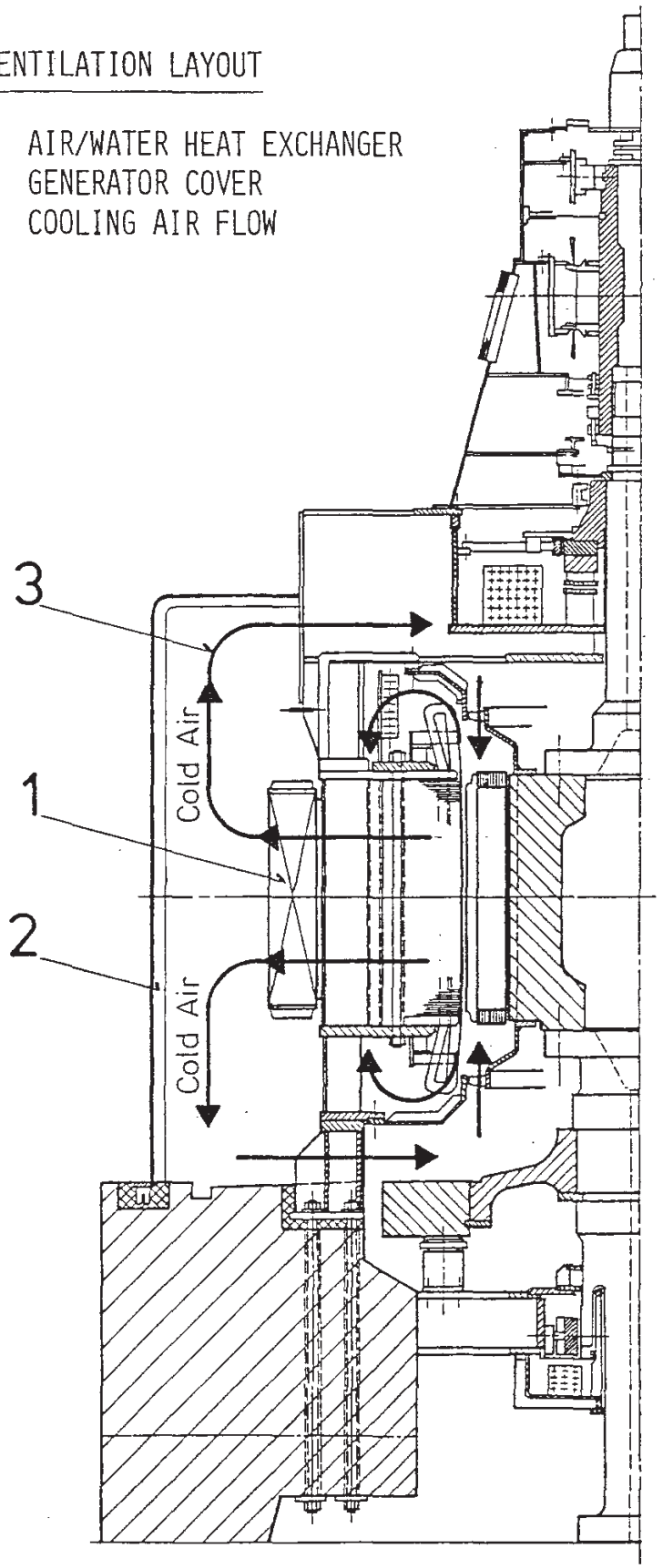
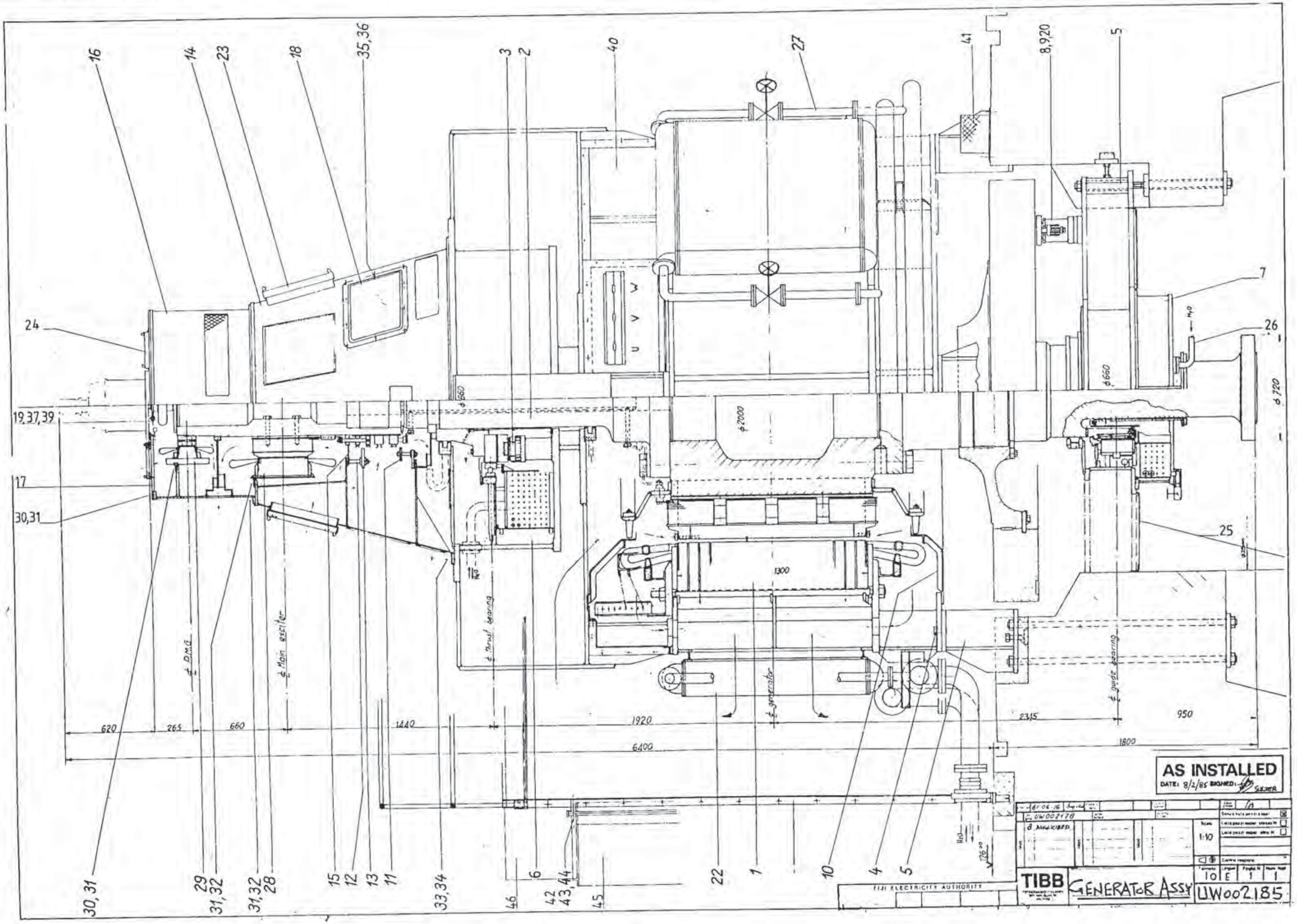


FIG No 7


AS INSTALLED
DATE: 8/2/85 SIGNED:
TIBB
GENERATOR ASSY
UW002185
FIJI ELECTRICITY AUTHORITY
1:10
10 E 1 1
UW002178
℄ generator
℄ thrust bearing
℄ guide bearing
℄ Main exciter
℄ DMG
ϕ2000
ϕ660
ϕ720
1300
620
265
660
1440
1920
2315
950
1800
6400
U V W
16
14
23
18
35,36
3
2
40
27
41
8,920
5
7
26
25
24
19,37,39
17
30,31
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31,32
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33,34
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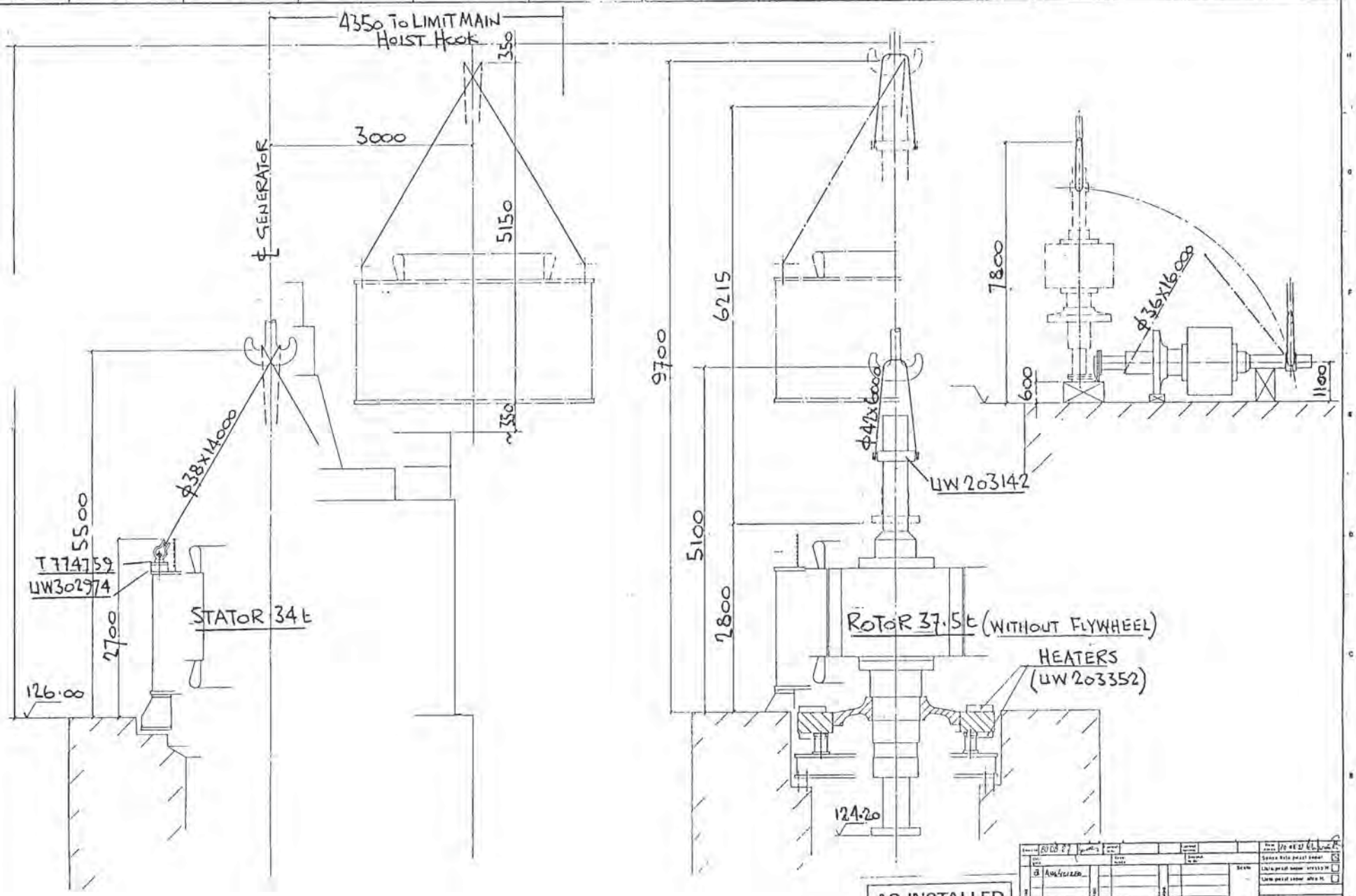
46
42
43,44
45
22
1
10
4



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DATE: 8/2/25 SIGNED:

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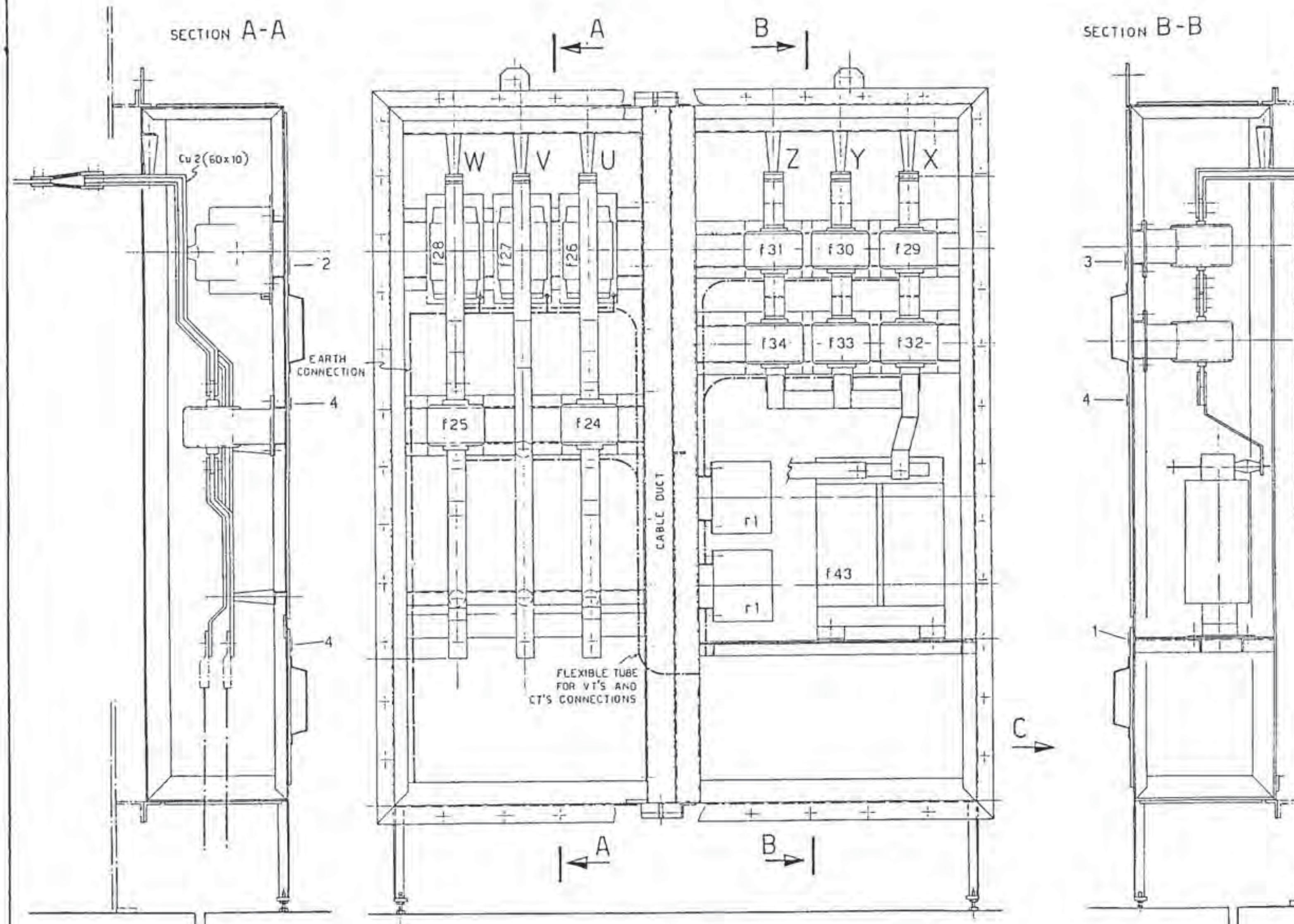
TIBB

MOVEMENTS IN POWER STATION

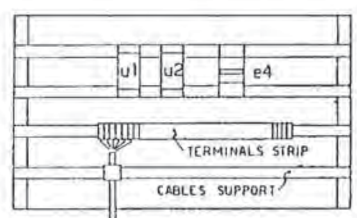
UW103755a

UW 103755



EQUIPMENT	
POS.	DESCRIPTION
f24-25	C.T.S 1500/1 A 30 VA cl. 0,2
f26÷28	V.T.'S core1 200 VA cl.1 - core2 30 VA cl.3P 11000:√3/110:√3/110:3
f29÷31	C.T.'S 1500/1/1 core1 30 VA-5P10 core2 30VA-5P10
f32÷34	C.T.'S 1500/1 cl.x
f43	10 kVA/CONTINOUS 30 kVA/30 sec
r1	R.=1,439 ohm I.=103 A/30 sec
e4	THREE POLE AUTOMATIC CIRCUIT BREAKER 6 A 110V 50Hz
u1-2	REVOLUTION TRANSDUCERS

VIEW C



LABELS LIST

1 LV Compartment
2 STATOR LINE TERMINAL COMPARTMENT
3 STATOR NEUTRAL COMPARTMENT
4 "DANGER HIGH VOLTAGE"

REDRAWN FOR INSTRUCTION MANUAL

TIBB

11kV SWGR - STAR POINT AND EARTHING TRANSFORMER EQUIPMENT ARRANGEMENT

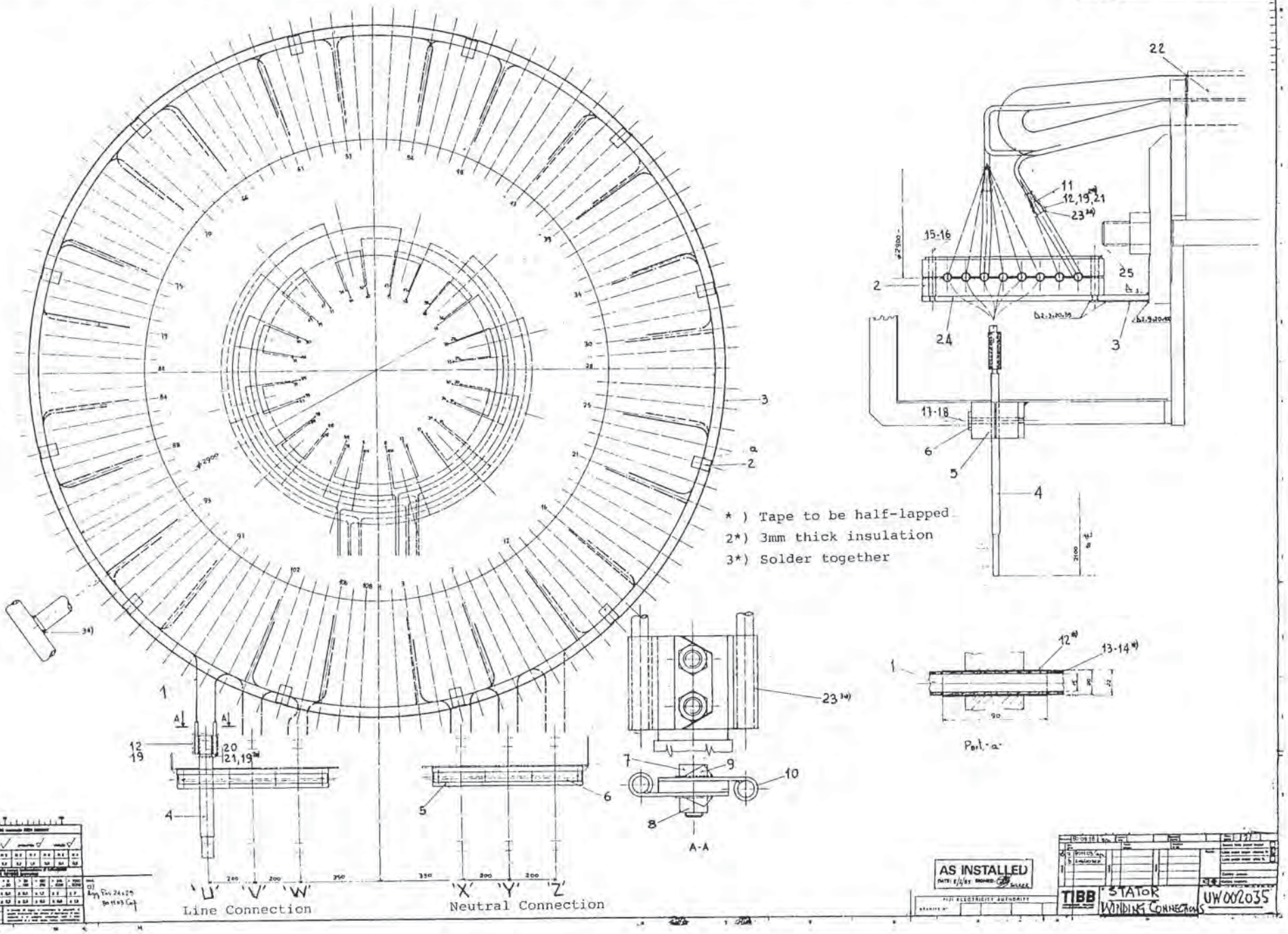
Scale 1:10

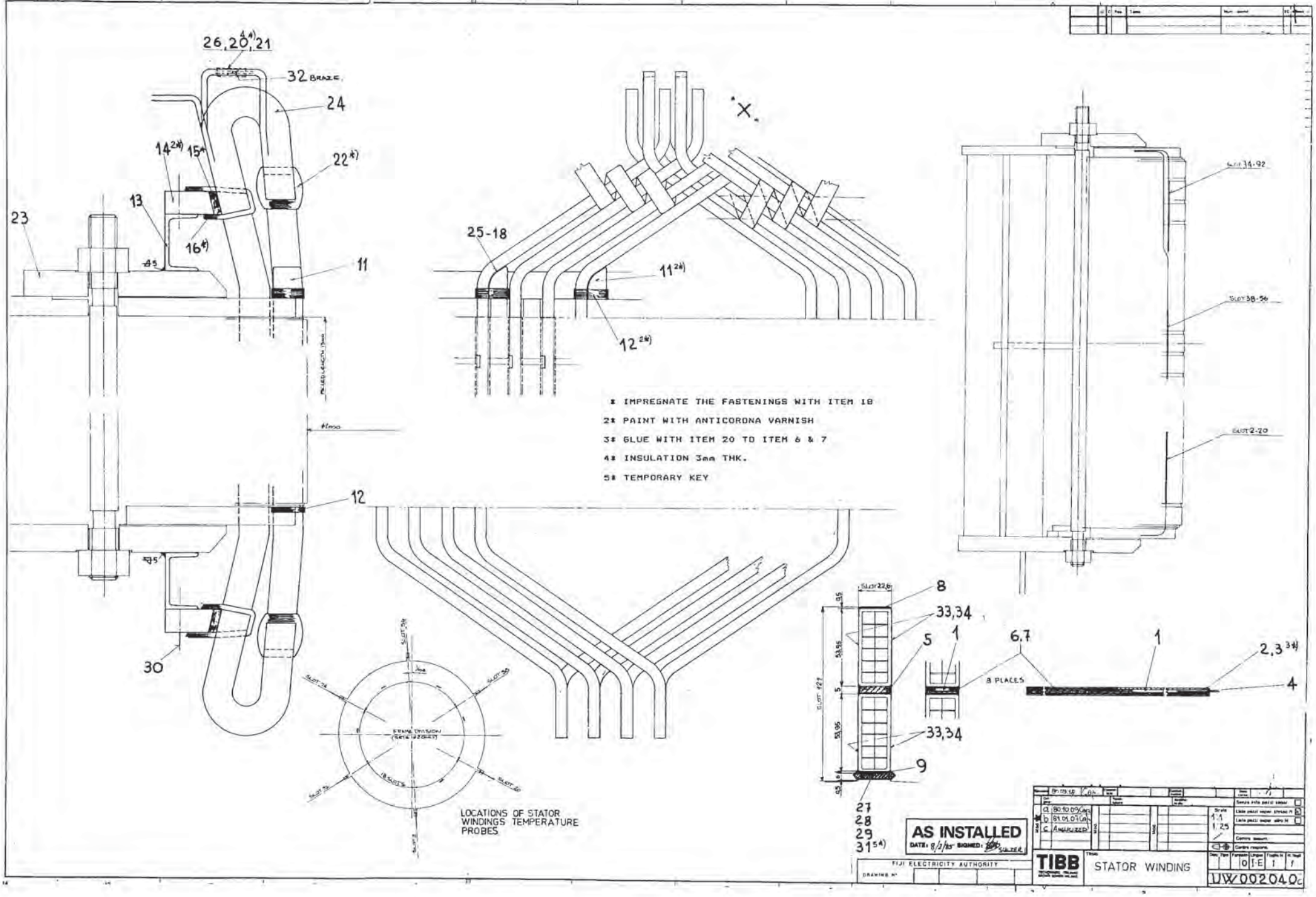
11-2-81 · 81.02.16

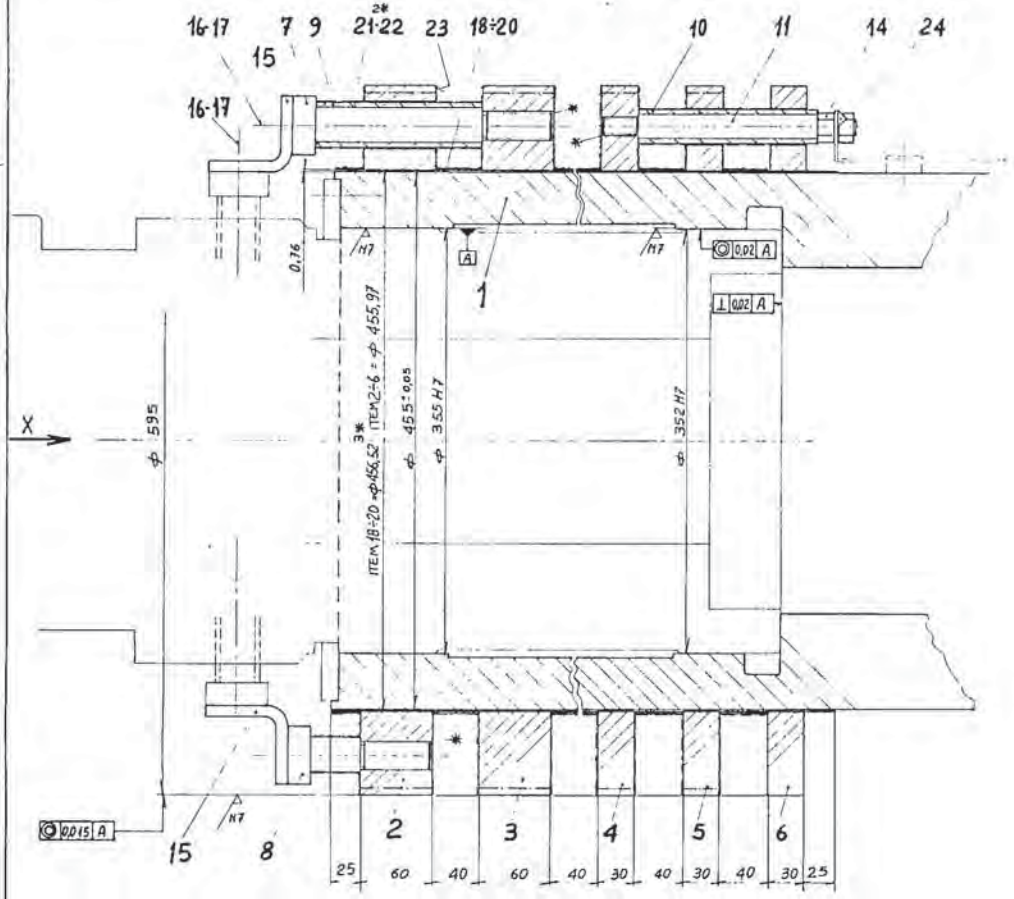
2PF · 2PT

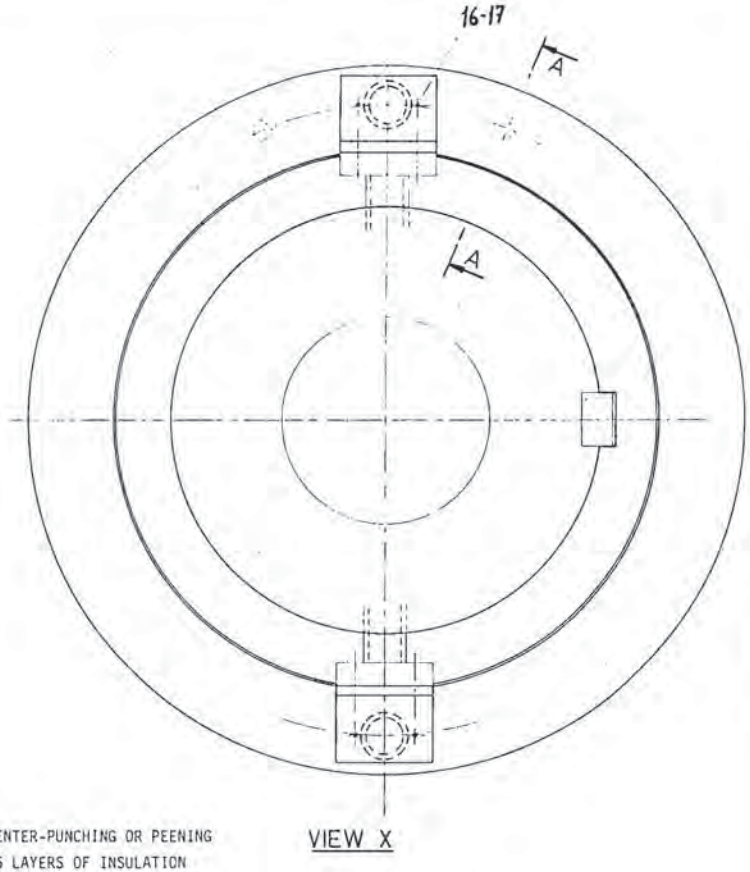
Z A0 E 1 1

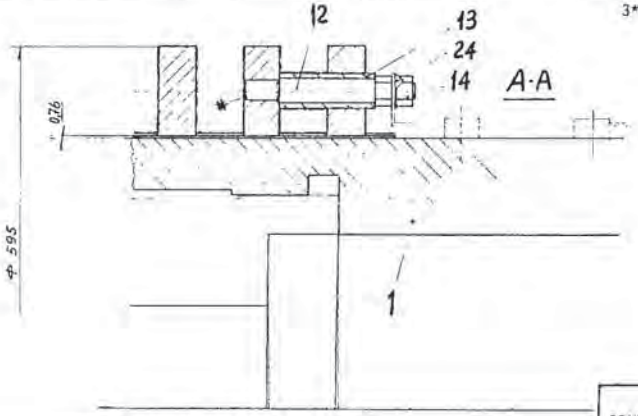
UQR 000214


22
11
12,19,21
23 3)
15-16
25
2
24
3
17-18
6
5
4
3
2
1
12
19
20
21,19 3)
4
5
6
23 3)
7
9
10
8
A-A
1
12 4)
13-14 4)
90
Part - a -
'U' 'V' 'W'
Line Connection
'X' 'Y' 'Z'
Neutral Connection
*) Tape to be half-lapped
2*) 3mm thick insulation
3*) Solder together
AS INSTALLED
TIBB
STATOR
WINDING CONNECTIONS
UW002035
UW 002035


26,20,21 4*)
32 BRAZE
24
14 2*) 15*
22*)
13
16*)
23
11
12
30
25-18
11 2*)
12 2*)
X
SLOT 34-92
SLOT 38-56
SLOT 2-20
* IMPREGNATE THE FASTENINGS WITH ITEM 18
2* PAINT WITH ANTICORONA VARNISH
3* GLUE WITH ITEM 20 TO ITEM 6 & 7
4* INSULATION 3mm THK.
5* TEMPORARY KEY
SLOT 22-8
8
33,34
5
1
6,7
8 PLACES
1
2,3 3*)
4
33,34
9
27
28
29
31 5*)
LOCATIONS OF STATOR WINDINGS TEMPERATURE PROBES
AS INSTALLED
DATE: 8/2/85 SIGNED:
FIJI ELECTRICITY AUTHORITY
TIBB
STATOR WINDING
UW002040c







* FASTEN BY CENTER-PUNCHING OR PEENING
2* ITEM 21 IS 5 LAYERS OF INSULATION
3* INTERFERENCE FIT = 1.2%

AS INSTALLED
DATE: 8/2/85 SIGNED: SULZER

FIJI ELECTRICITY AUTHORITY
DRAWING N°

TIBB

80-09-30

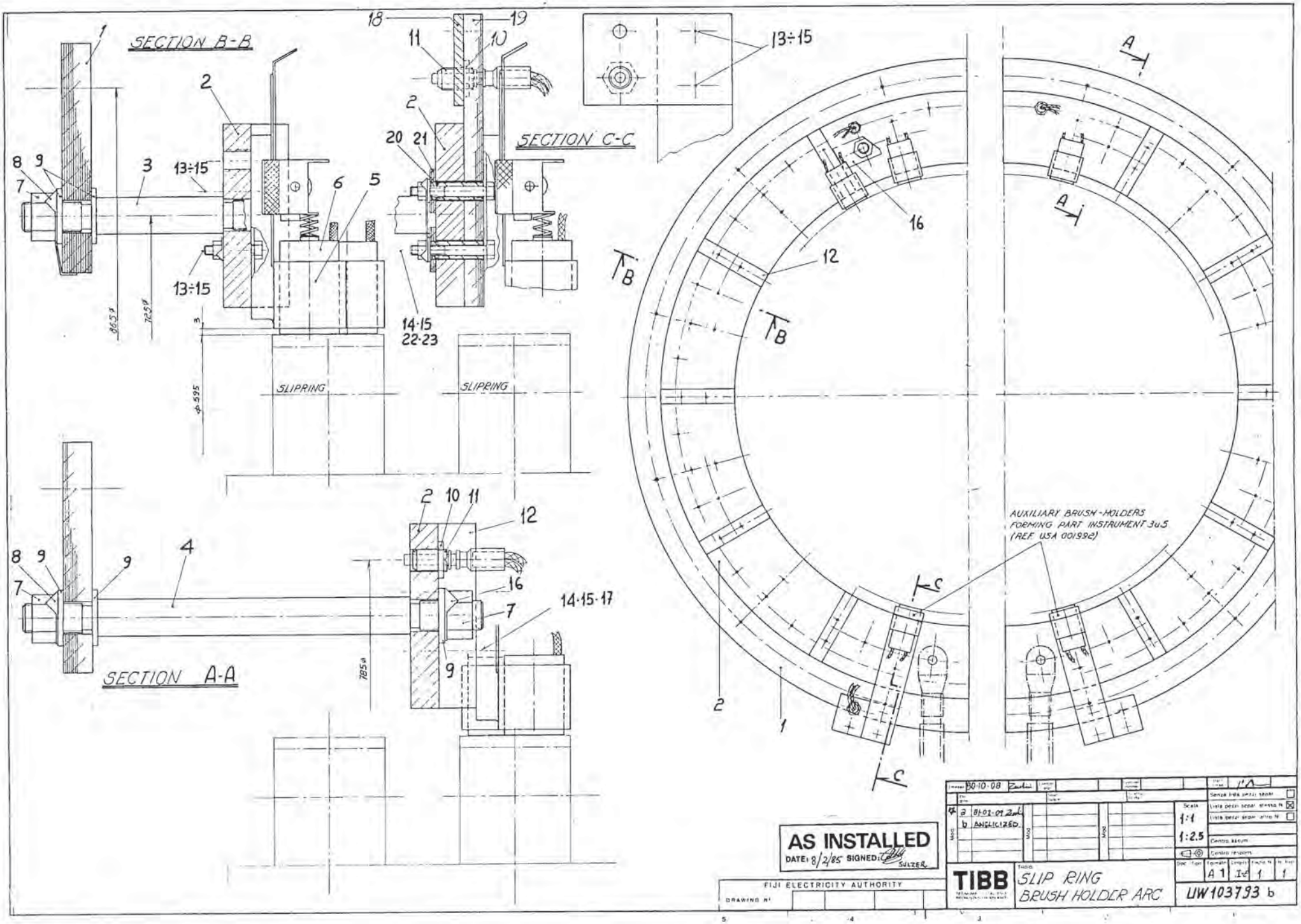
a ANNULLED

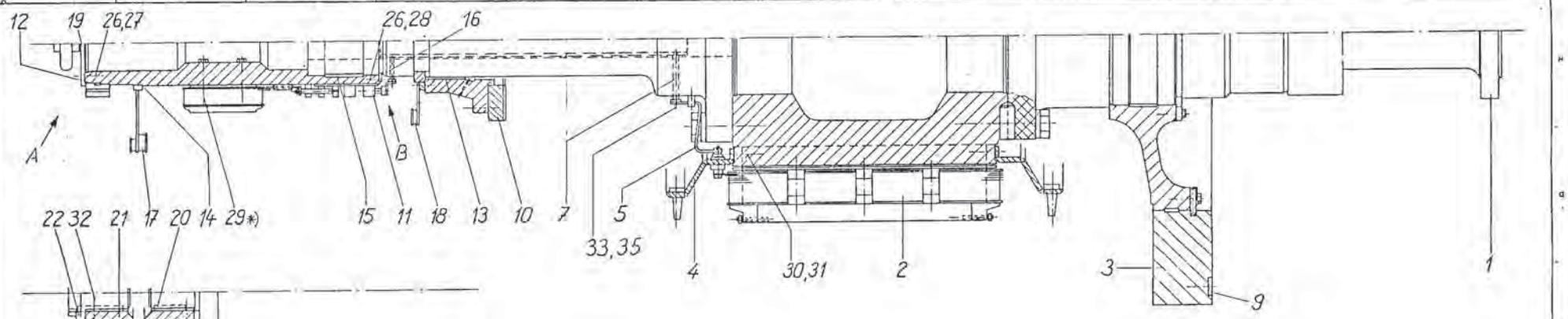
Scale 1:2.5

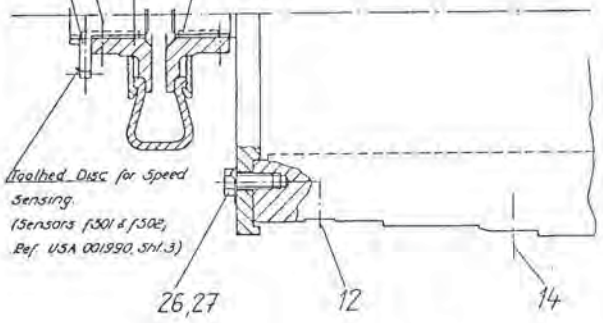
SLIP RINGS

A1 | 1 | 1 | 1

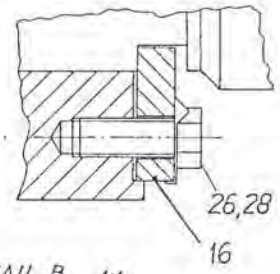
UW 103787 a


SECTION B-B
SECTION C-C
SECTION A-A
SLIPRING
SLIPRING
AUXILIARY BRUSH-HOLDERS FORMING PART INSTRUMENT 3uS (REF. USA 001992)
13÷15
14·15
22·23
14·15·17
AS INSTALLED
DATE: 8/2/85 SIGNED:
SULZER
FIJI ELECTRICITY AUTHORITY
TIBB
SLIP RING BRUSH HOLDER ARC
UW103793 b
30·10·08
a 81·02·09
b ANTICIRED.
Scala 1:1 1:2.5
A1

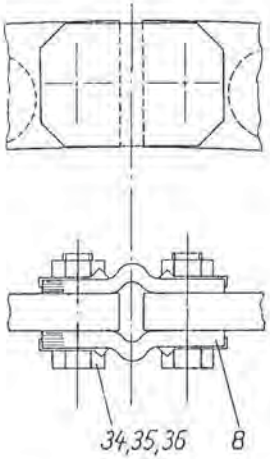




DETAIL A 1:2.5

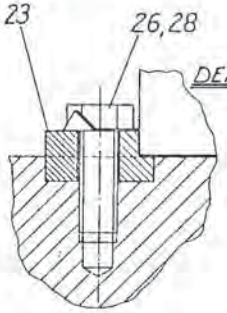


DETAIL B 1:1

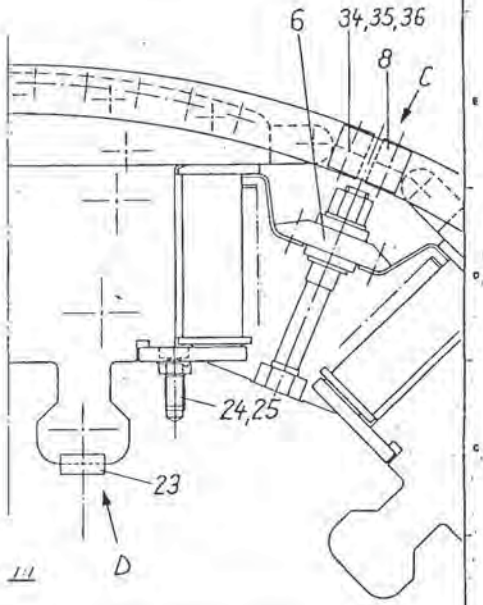


DETAIL C 1:1

*) TIGHTENING TORQUE = 110 kg.m



DETAIL D 1:1



AS INSTALLED
DATE: 8/2/85 SIGNED: SULZER

W901016

UW 103713

FIJI ELECTRICITY AUTHORITY
DRAWING Nº

TIBB

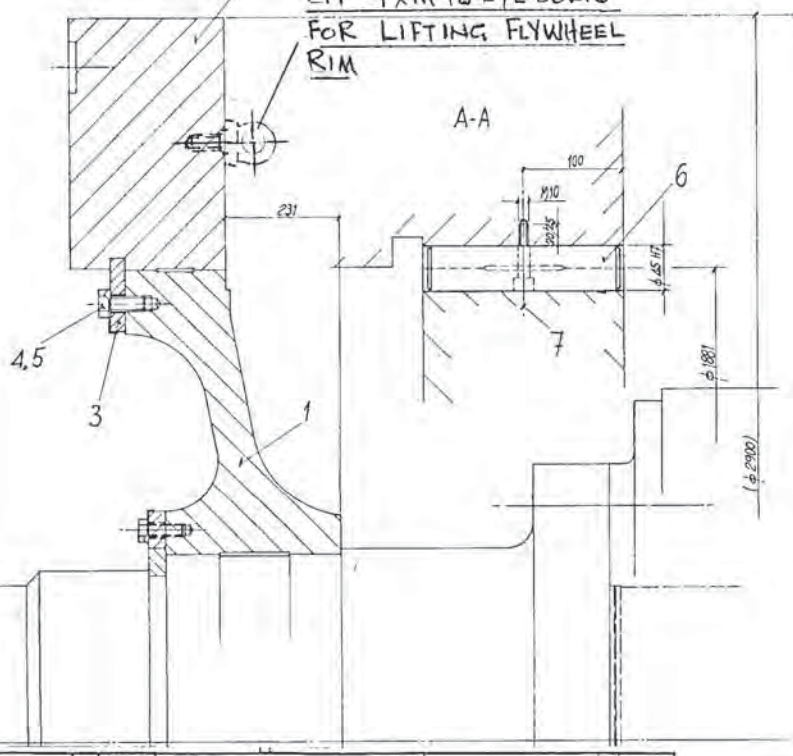
ROTOR COMPLETE

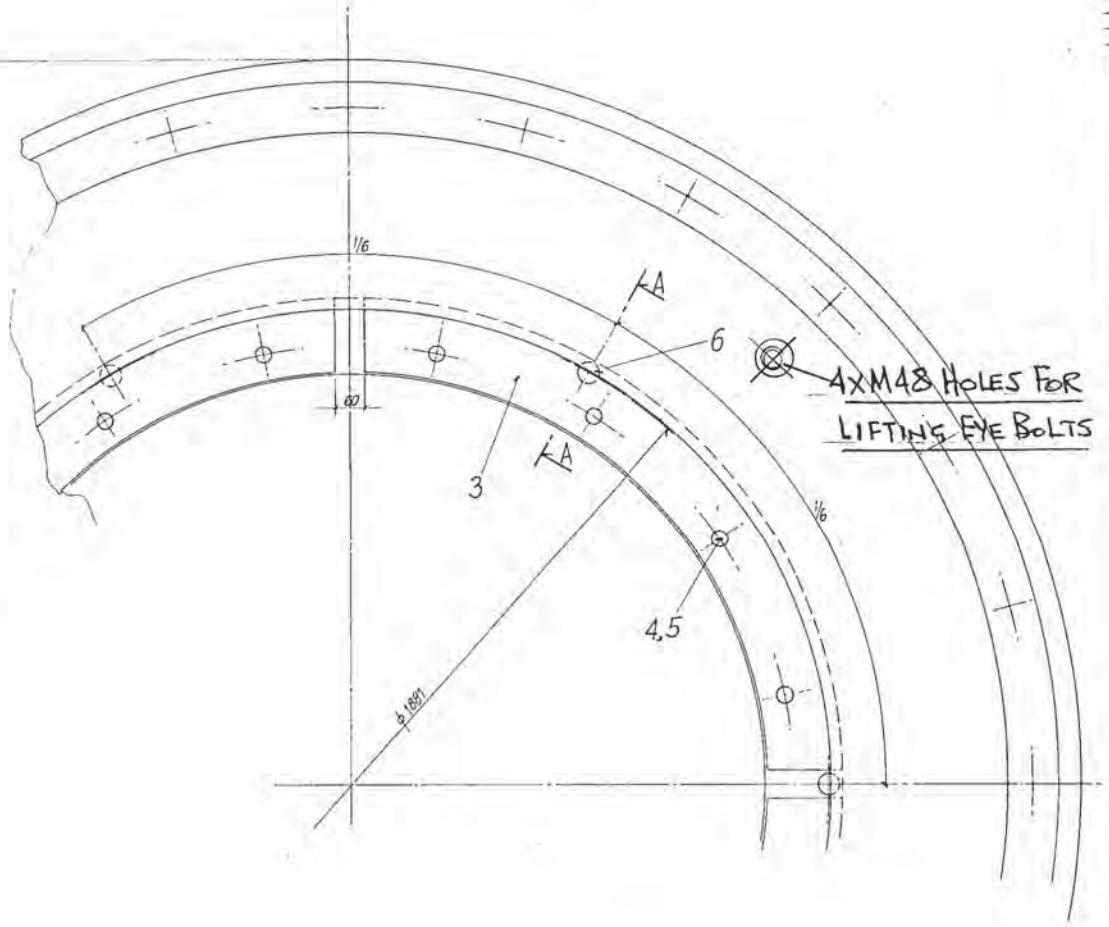
UW 103713a.

* HEAT RIM(2) WITH SPECIAL TOOLS UW 203352 TO 30°C ABOVE AMBIENT FOR ASSEMBLY AND DISMANTLING

2 *)

FIT 4XM48 EYE BOLTS FOR LIFTING FLYWHEEL RIM





4XM48 HOLES FOR LIFTING EYE BOLTS

Per le rubr.: N. rubr. / Per le pos.: quant./rubr.	U	C	Pos.	Testo	Num. identif.	EC	Massa/U
1				FLYWHEEL ASSEMBLY	UW 103641 R1		32 lo
1			1	ROTOR WITH FWHEEL HUB	UW 203071 R1		
1			2	FLYWHEEL RIM	UW 103078 P1		
4			3	LOCKING PLATES	UW 103811 P1		
16			4	SETSCREW M30X70			
16			5	LOCKING WASHER	UW 302824 P1		
6			6	DOWEL PIN (PARALLEL)	UW 40A 227 P1		
6			7	SETSCREW M10X50			

FIJI ELECTRICITY AUTHORITY

DRAWING N°

TIBB

Scale 15

Senza lista pezzi separ.

Lista pezzi separ. allestim.

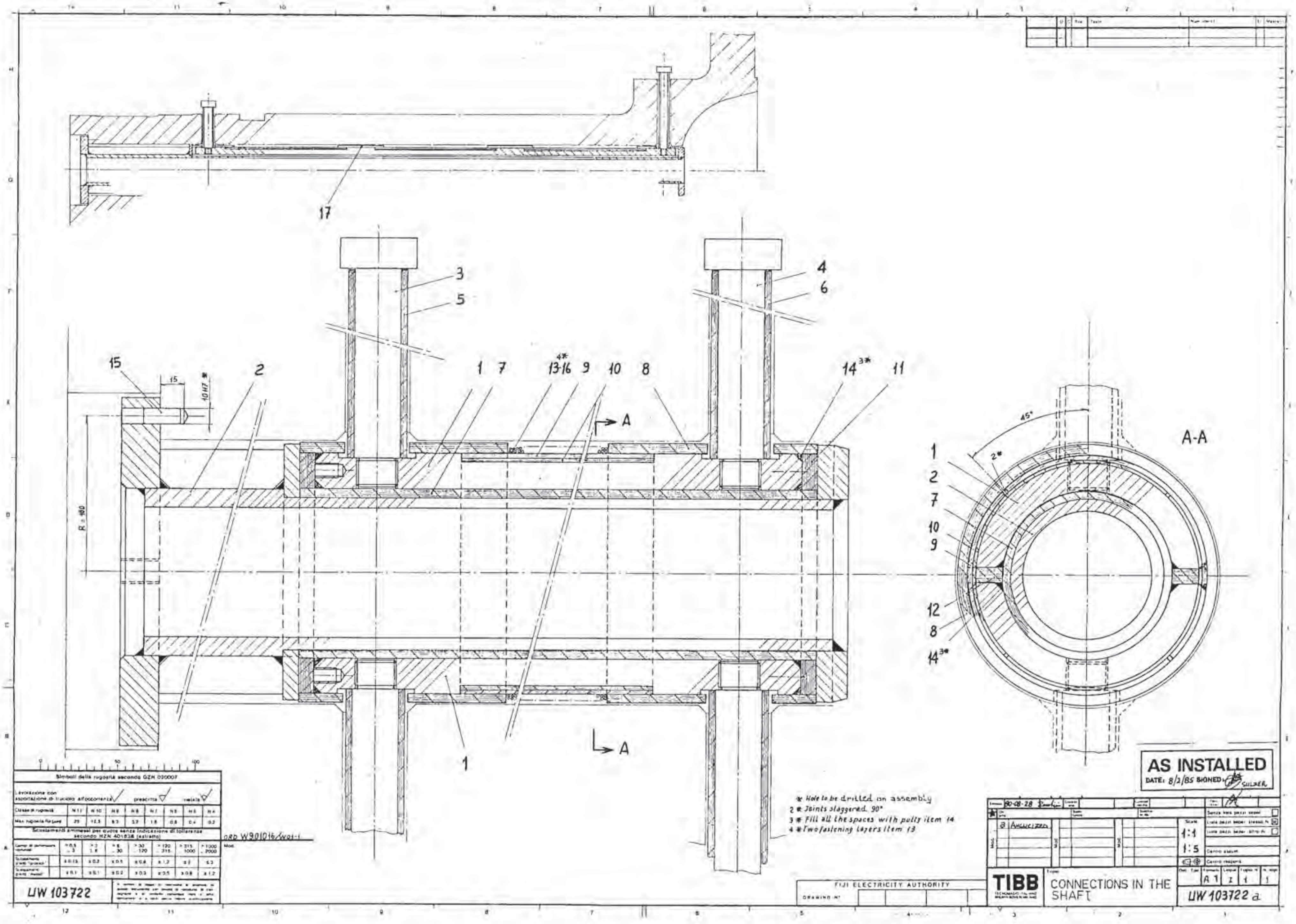
Lista pezzi separ. altro

Centro assum.

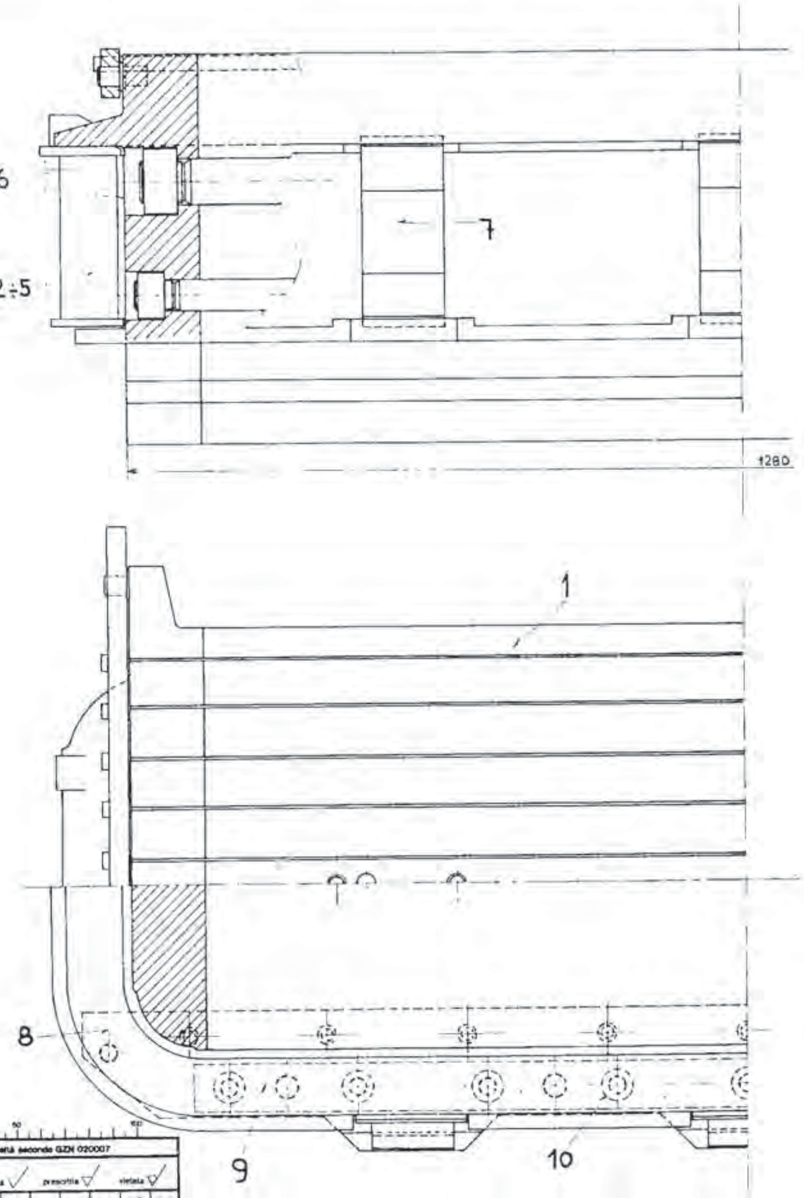
Centro respons.

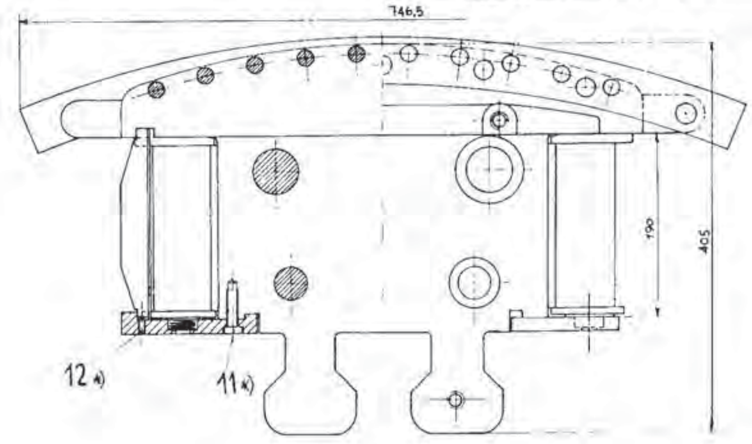
Title: FLYWHEEL ASSEMBLY

UW 103641

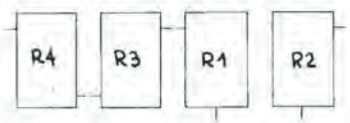


17
3
5
4
6
15
2
1 7
4*
13-16 9 10 8
14 3* 11
A
A
1
A-A
45°
2*
1
2
7
10
9
12
8
14 3*
R = 180
15
10 H7 *
Simboli della rugosità secondo GZN 020007
ORD W901016/W01-1
UW 103722
* Hole to be drilled on assembly
2 * Joints staggered 90°
3 * Fill all the spaces with putty item 14
4 * Two fastening layers item 13
AS INSTALLED
DATE: 8/2/85 SIGNED:
SULZER
FIJI ELECTRICITY AUTHORITY
DRAWING Nº
TIBB
CONNECTIONS IN THE SHAFT
1:1
1:5
A 1
UW 103722 a
80-08-28
a AMUCIZED





*) FIX BY CENTERPUNCHING OR BURRING.



COMPRESSED POLE	1225 KG
POLE WINDING	290 KG
POLE INSULATION	17 KG
DAMPER WINDING	35 KG
POLE WEDGE	22 KG
MISCELLANEOUS	61 KG
1 POLE = TOTAL	1650 KG
8 POLES = TOTAL	13200 KG

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DATE: 8/2/85 SIGNED:

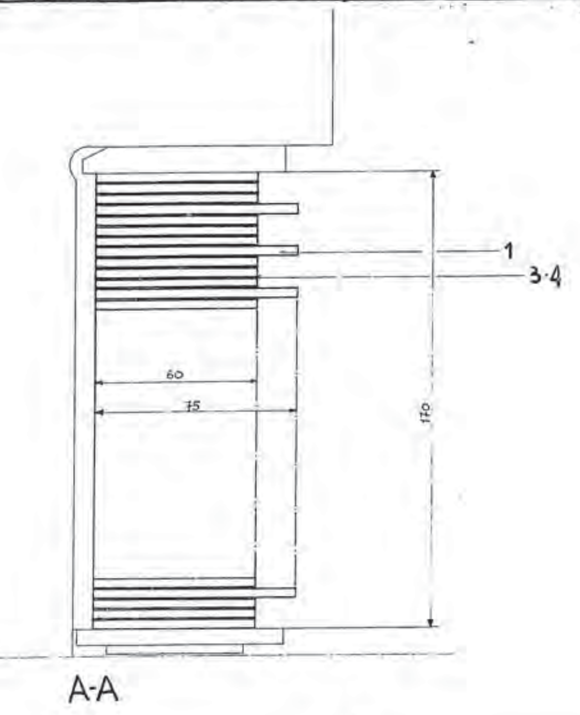
FIJI ELECTRICITY AUTHORITY

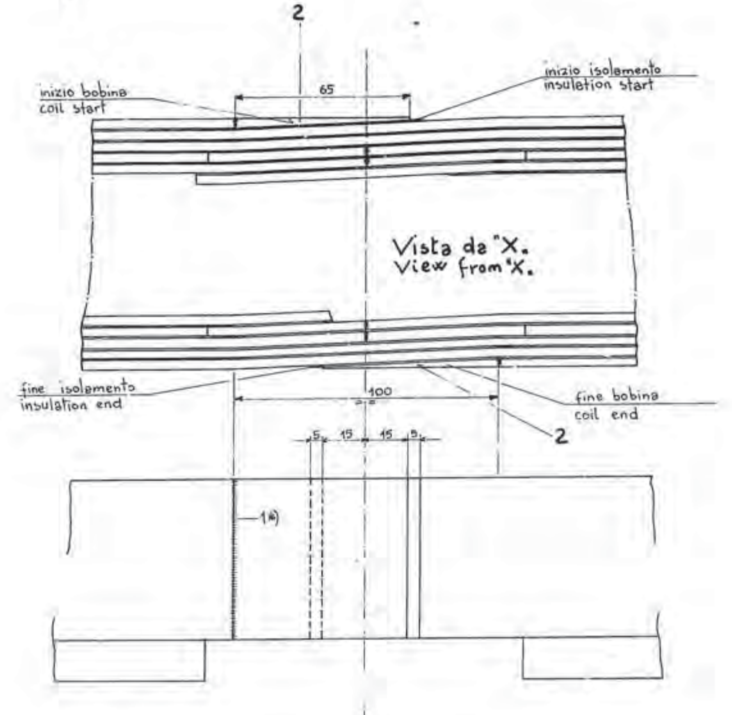
TIBB

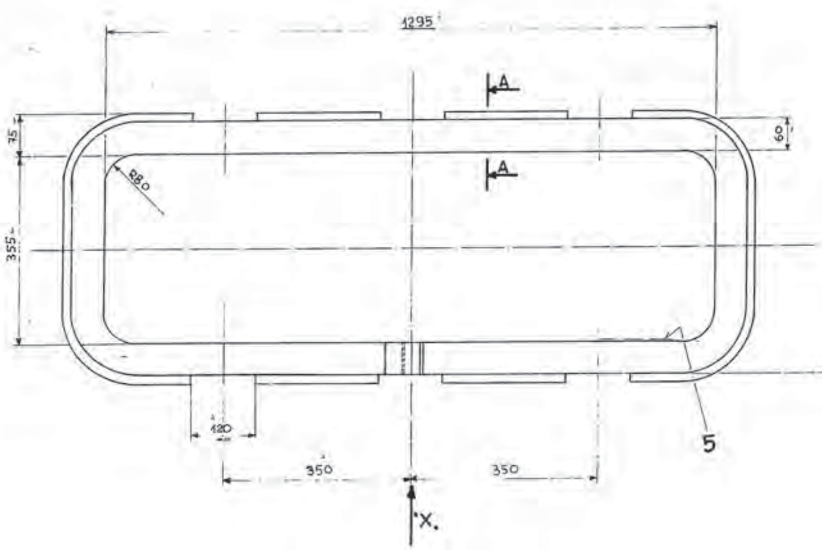
POLE ASSEMBLY

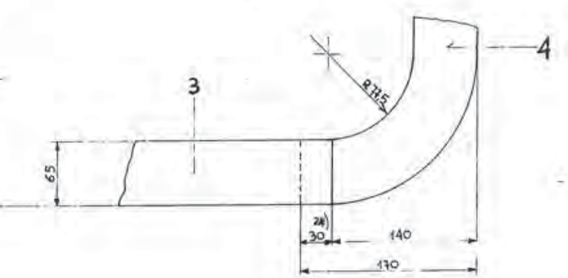
UW103631a

UW103631









COMPOSIZIONE E ALTEZZA DELLA BOBINA COIL COMPOSITION END HEIGHT	
N°43 spire (33+10) sp. 3,5 N°43 thread (33+10) th. 3,5	150,5
N°42 spire isol. (2x0,22) press. 0,4 N°42 insul. thread (2x0,22) press. 0,4	16,8
Tolleranza aggiuntiva added tolerance	2,7
Totale Total	170

mm

PESO BOBINA COIL WEIGHT	
Rame spire normali Normal thread Cu	206,7
Rame spire di ventilazione Ventilation thread Cu	79,4
Isolamento + vernice Insulation + paint	3,9
Peso Totale 1 bobine isol. Total weight 1 insulated thread	290

Kg.

Superficie di 1 spira normale = 2010 cm²
1 normal coil surface = 2010 cm²

Marr & McLellan & Partners
SYDNEY
File Number 271.08 | 545 A
Date 14 8 81

OSSERVAZIONI NOTES

1*) - lisciare accuratamente dopo la saldatura.
- burnisch carefully after welding.

2*) - l'isolamento delle spire è formato da 2 strati di Nomex pos. 3 e 4 sovrapposte sfalsati.
- thread insulation is made with 2 overlapped and staggered Nomex sheet pos. 3 and 4.

Simboli della rugosità secondo GZN 020007

Lavorazione con asportazione di truciolo: all'occorrenza / prescritta / vietata

Classe di rugosità	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4
Max. rugosità Ra (µm)	25	12,5	6,3	3,2	1,6	0,8	0,4	0,2

Scostamenti ammessi per quote senza indicazione di tolleranza secondo HZN 401638 (estratto)

Campi di dimensioni nominali	> 0,5 ... 3	> 3 ... 6	> 6 ... 30	> 30 ... 120	> 120 ... 315	> 315 ... 1000	> 1000 ... 2000
Scostamenti grado "grosso"	± 0,15	± 0,2	± 0,5	± 0,8	± 1,2	± 2	± 3
Scostamenti grado "medio" X	± 0,1	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2

A termini di legge ci riserviamo la proprietà di questo documento con divieto di riprodurlo, di comunicarlo a terzi senza nostra autorizzazione.

UW 103603

W9.01015/011

Mod. a) modif. larghezza Pos. 3 e 4 80.12.1 Cap.

FIJI ELECTRICITY AUTHORITY
DRAWING Nº 34 M10 139

Eseguito 80.05.09 Cap.
Ott. gen. UW 102742
a 80.12.1 Cap.

TIBB Tecnomasio Italiano Brown Boveri Milano

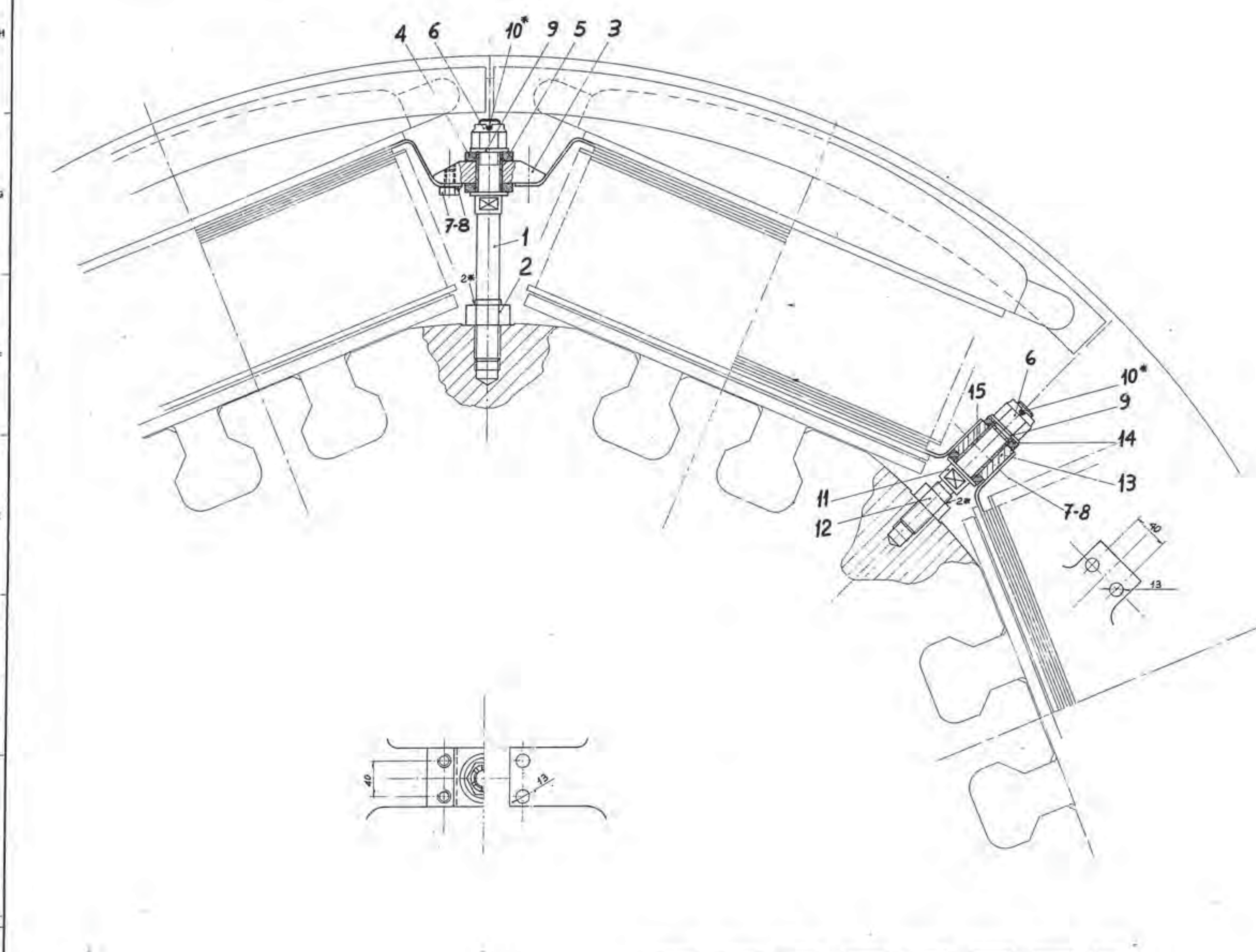
Titolo: Avvolg. Polo - Rame
Pole winding - Cu

Scala 1:1 1:2,5 1:5

Data emis. 80.05.12

Doc. Tipo / Formato 1 / Lingua I-E / Foglio N. 1 / N. fogli 1

UW 103603



* Foro φ 5 da eseguire al montaggio - Hole to be carried out at the assembling
2* Assicurare con bulino - Secure with burin

Simboli della rugosità secondo GZN 020007

Lavorazione con asportazione di truciolo: all'occorrenza √ prescritta ▽ vietata ○

Classe di rugosità	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4
Max. rugosità Ra (μm)	25	12,5	6,3	3,2	1,6	0,8	0,4	0,2

Scostamenti ammessi per quote senza indicazione di tolleranza secondo HZN 401638 (estratto)

Campi di dimensioni nominali	> 0,5 ... 3	> 3 ... 6	> 6 ... 30	> 30 ... 120	> 120 ... 315	> 315 ... 1000	> 1000 ... 2000
Scostamenti grado "grossolano"	± 0,15	± 0,2	± 0,5	± 0,8	± 1,2	± 2	± 3
Scostamenti grado "medio"	± 0,1	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2

UW 103720

ORD. W9.01016/W01/1

Mod.

FIJI ELECTRICITY AUTHORITY
DRAWING N° 34 M10 152

Merz & McLellan & Partners
SYDNEY
File Number
Date

Disegn. 30-08-06

TIBB
TECNOMASIO ITALIANO BROWN BOVERI MILANO

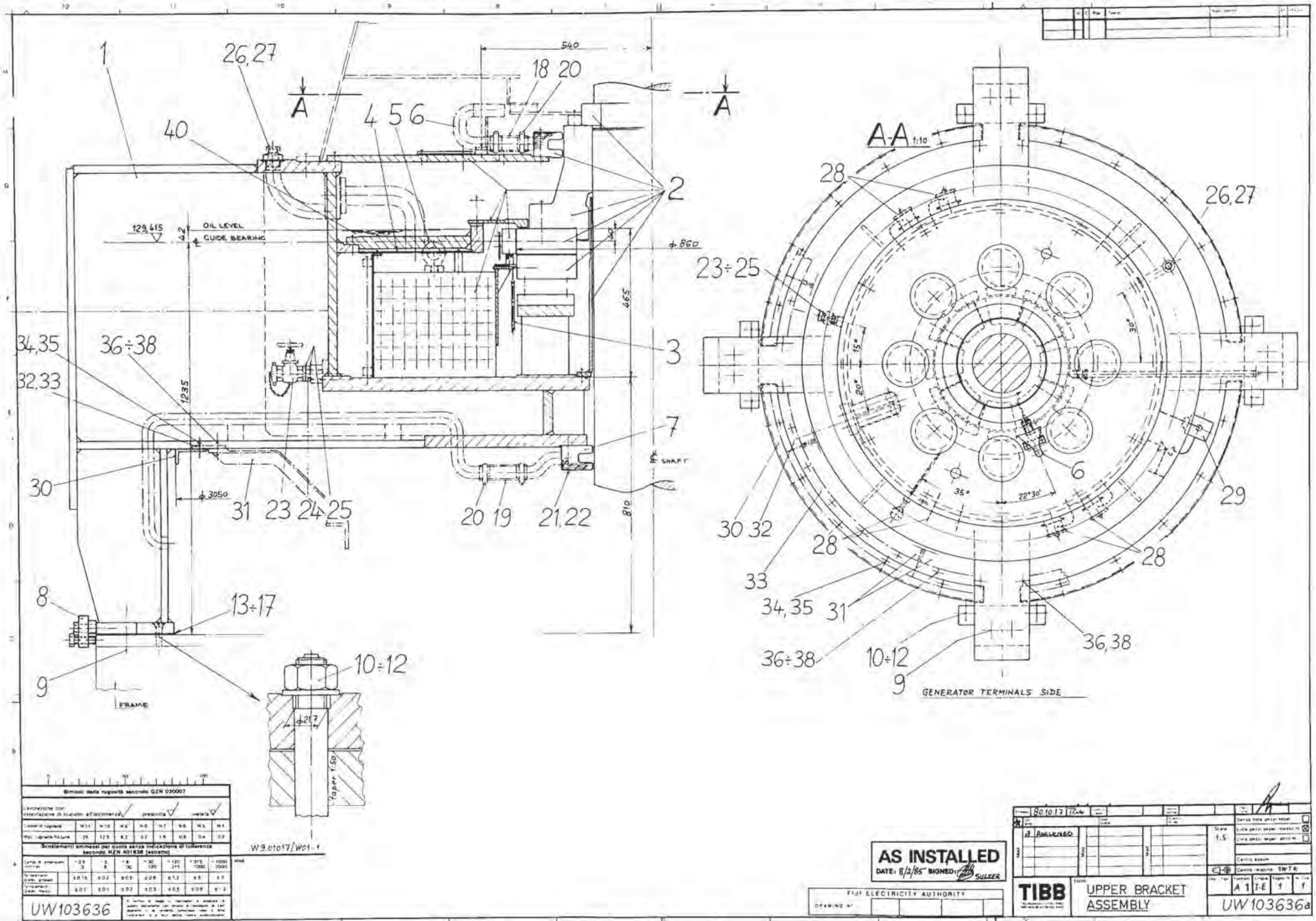
Titolo
POLE CONNECTIONS
CONNESSIONI POLI

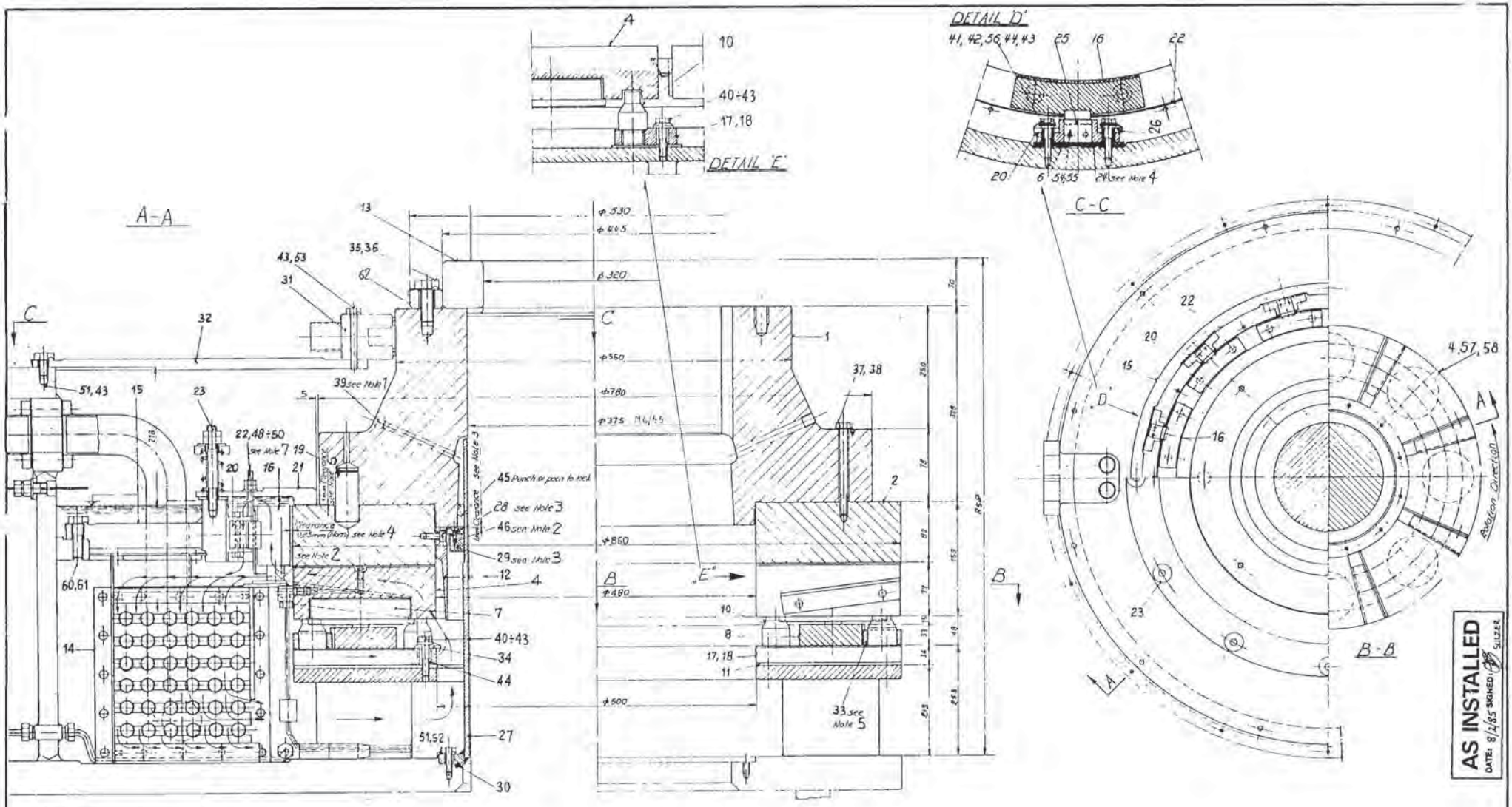
Scale 1:2,5

Senza lista pezzi separ. ☐
Lista pezzi separ. stesso N. ☒
Lista pezzi separ. altro N. ☐
Centro assunt.
Centro respons.

Doc.	Tipo	Formato	Lingua	Foglio N.	N. fogli
		A1	I	1	1

UW 103720


A
A
AA 1:10
1
2
3
4 5 6
7
8
9
10÷12
13÷17
18 20
20 19
21,22
23 24 25
23÷25
26,27
28
29
30
30 32
31
32,33
33
34,35
36÷38
36,38
40
540
465
810
ϕ 860
ϕ 3050
ϕ 21,7
1235
129,415
OIL LEVEL
GUIDE BEARING
SHAFT
FRAME
Taper 1:50
30°
15°
20°
35°
22°30'
GENERATOR TERMINALS SIDE
Simboli della rugosità secondo GZN 020007
Scostamenti ammessi per quote senza indicazione di tolleranza secondo NZN 401638 (estratto)
W9.01017/W01-1
UW103636
AS INSTALLED
DATE: 8/2/85 SIGNED: SULZER
FIJI ELECTRICITY AUTHORITY
DRAWING Nº
TIBB
UPPER BRACKET
ASSEMBLY
1:5
A1
UW103636a

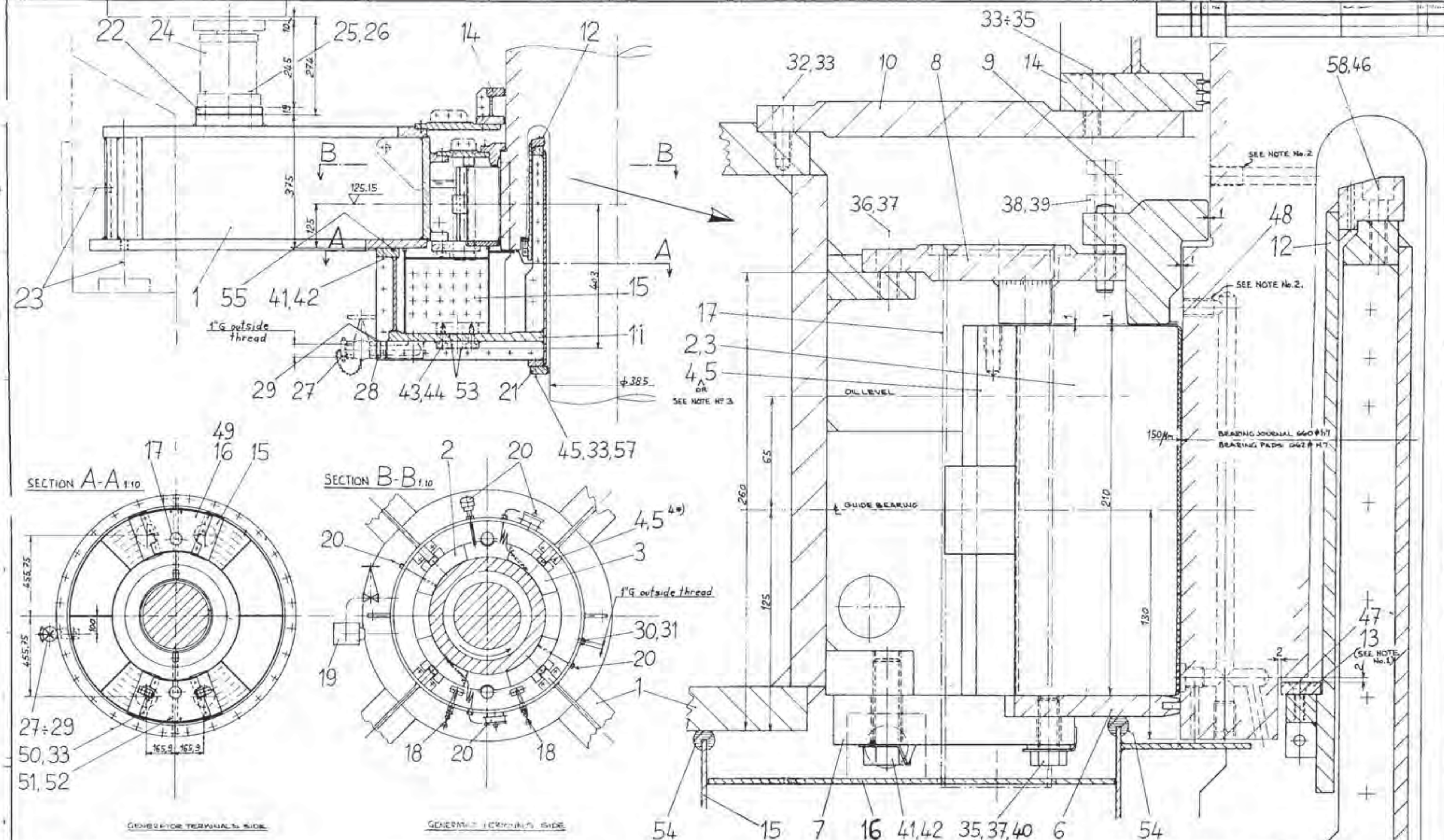


NOTES:

1. PLUG ON ASSEMBLY AS NOTED ON DRG. 271.08.5089/90/91/92, ITEM 39. PEEN OR PUNCH TO LOCK PLUG.
2. FILL THE HOLE WITH ARALDITE TO THE LEVEL OF THE SURROUNDING MATERIAL.
3. TO SET 1MM CLEARANCE (ROTOR MUST BE ON JACKS);
   A) ASSEMBLE RINGS #28 & #29 OVER THE INNER TUBE #27
   B) PLACE 1MM STRIPS ON TOP OF #29
   C) ASSEMBLE ITEMS #1 TO #13 (THRUST BEARING)
   D) LOWER ROTOR ON TO THRUST PADS THEN RAISE AGAIN
   E) DISASSEMBLE ITEMS #1 TO #13 AND REMOVE 1MM STRIPS
   F) WELD RING #29 TO TUBE #21
4. RADIAL CLEARANCE IS TO BE SET TO DIMENSIONS NOTED ON DRG. 271.08.5089/90/91/92, ITEM 11 AND SUFFICIENT SHIMS #24 ARE TO BE INSERTED BEHIND THE PAD SUPPORT ASSEMBLY.
5. ASSEMBLE ITEM #33 ON OUTER ITEM #10 AND WELD IN PLACE.
6. CLEARANCE CAN BE ADJUSTED WITH SHIMS UNDER COVER #21 AT COVER FASTENING #23 - TOL. +0.0 - 0.5MM
7. THE TOP OF PAD #16 SHOULD LEVEL WITH RUNNER #2. TO ADJUST, GRIND THE SUPPORT PLATES TO SUIT.

LOAD ON THRUST BEARING	-	600 KN
SPEED	-	750 REVS/MIN
THRUST BEARING SURFACE AREA	-	2790 CM^2
THRUST BEARING NUMBER OF PADS	-	8
GUIDE BEARING SURFACE AREA	-	1545 CM^2
GUIDE BEARING NUMBER OF PADS	-	12
OIL CAPACITY OF RESERVOIR ABT	-	1070 L.CA
OIL QUALITY	-	$4,1^0E/50^0C$
COOLING SURFACE	-	130 M^2
QUANTITY OF COOLING WATER	-	290 L/MIN.

80.01.11	80.07.4				
W003924					
a) 80.11.05					
b) AMENDED					
TIBB	Title: THRUST/GUIDE BEARING ASSEMBLY.	Scale: /	Doc. Type: 4	Formats: 1	Lngues: I	Pages N°: 1	N. Sheet: 1
					UW 103392b



NOTES:

1. WHEN FIXING RING #13 (2 HALVES) TO CYLINDER #12 (2 HALVES), THE JOINS IN THE RING SHALL NOT COINCIDE WITH THE JOINS IN THE CYLINDER. LOCK SCREWS WITH ARALDITE.

2. OIL PUMPING & VENT HOLES ARE OPEN OR BLOCKED AS NOTED ON DRG 271:08:50 B9/90/91/92, ITEMS 22 & 23. THREADED PLUG MUST BE LOCKED WITH PEENING OR PUNCHING.

3. INITIALLY NOMINATED CLEARANCE BETWEEN PADS #2/#3 AND JOURNAL IS OBTAINED USING KEYS #4. WHERE THICKER KEYS ARE REQUIRED USE SPARE KEYS #5. MEASURING DATA IS SHOWN ON MUST BE REVISED ON DRG 271:08:50 B9/90/91/92 & EACH KEY SHOULD BE MARKED WITH POSITION NUMBER & THICKNESS.

W9 01017/W01/1

a) Aggiunta Pos. 49 80.12.10 Up to date 80.12.10

b) Up to date 81.02.24

c) Up to date 81.06.25

AS INSTALLED
DATE: 8/2/85 SIGNED: SULZER

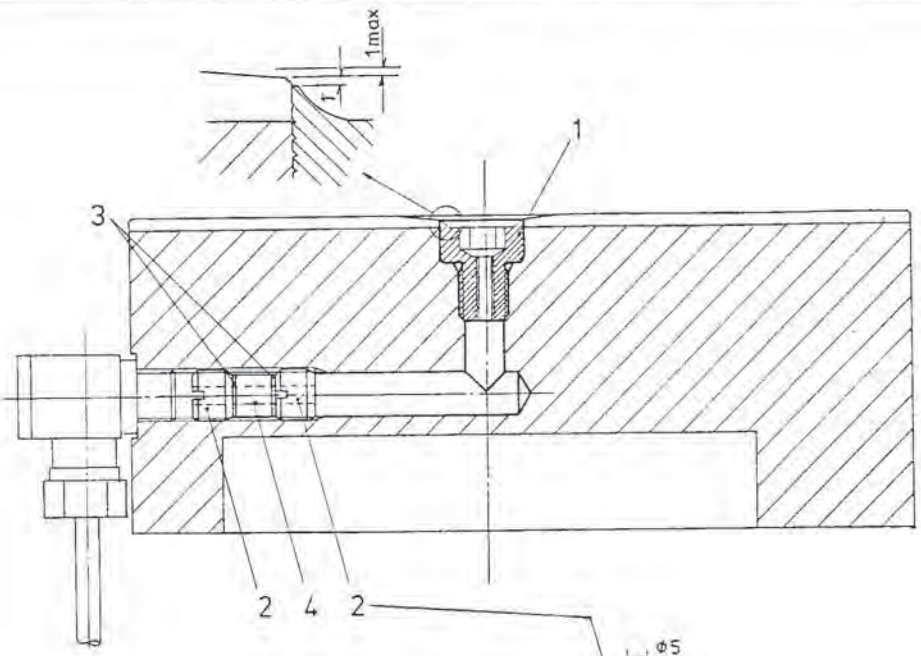
FIJI ELECTRICITY AUTHORITY

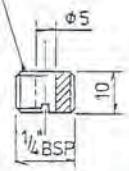
TIBB

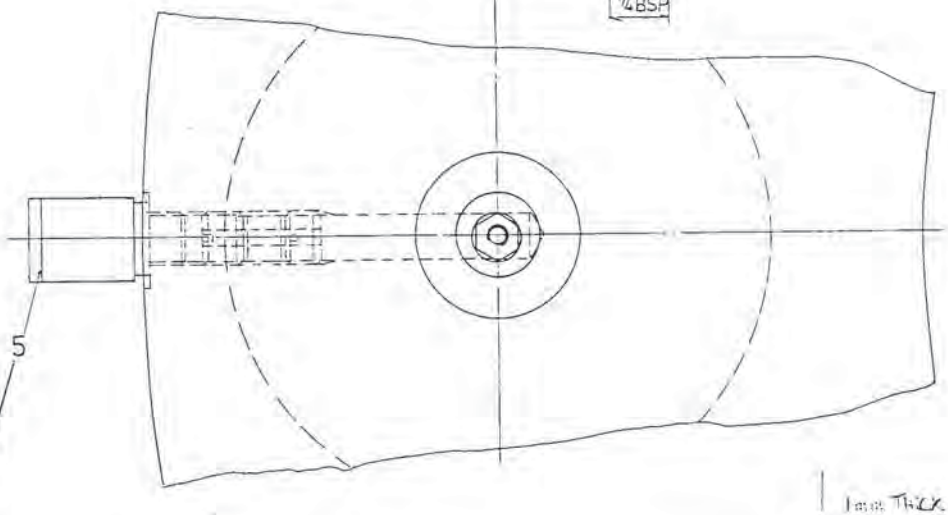
LOWER BEARING ASSEMBLY

UW103738

UW103738d





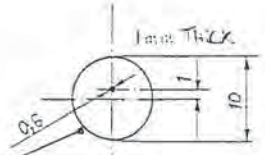


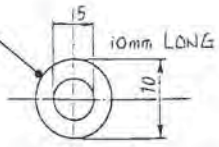
1 = OIL OUTLET

2 = RETAINING SCREWS

3 = ORIFICE PLATES

4 = SPACER TUBE

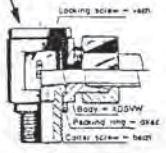




Series	Tube O. D.	Part No. complete coupling	Part No. for single parts: body Form W	body Form T	locking screw	collar screw	packing ring
S	6	6-SR	XDSVW 6-SR	XDSVT 6-SR	vsch M 18 x 1	bsch R 1/4"	dkaz R 1/4"
	8	8-SR	XDSVW 8-SR	XDSVT 8-SR	vsch M 18 x 1	bsch R 1/4"	dkaz R 1/4"
	10	10-SR	XDSVW 10-SR	XDSVT 10-SR	vsch M 22 x 1,5	bsch R 1/4"	dkaz R 1/4"
	12	12-SR	XDSVW 12-SR	XDSVT 12-SR	vsch M 22 x 1,5	bsch R 1/4"	dkaz R 1/4"
	14	14-SR	XDSVW 14-SR	XDSVT 14-SR	vsch M 26 x 1,5	bsch R 1/4"	dkaz R 1/4"
	16	16-SR	XDSVW 16-SR	XDSVT 16-SR	vsch M 26 x 1,5	bsch R 1/4"	dkaz R 1/4"
	20	20-SR	XDSVW 20-SR	XDSVT 20-SR	vsch M 26 x 1,5	bsch R 1/4"	dkaz R 1/4"

DSVW

DSVT



ERMETO Armaturen GmbH

Australia Agent:

R & D Hydraulics
37 Pine Street,
Hawthorne, Victoria.
'phone (03)861.5003.
Telex AA38485.
P.O.Box 202, HAWTHORNE, 3122.

Emesso	79-10-08	Bagnato	Controllato	79.10.10	Rovera	Controllo norme	Data corso 79/10/10
Origine			Sostituisce			Sostituito da	Senza lista pezzi separ.
Mod. 236	REDRAWN FROM ORIGINALS UW 202855 UW 403906		Mod.		Mod.		Scala /
							Lista pezzi separ. stesso N.
							Lista pezzi separ. altro N.
							Centro respons.

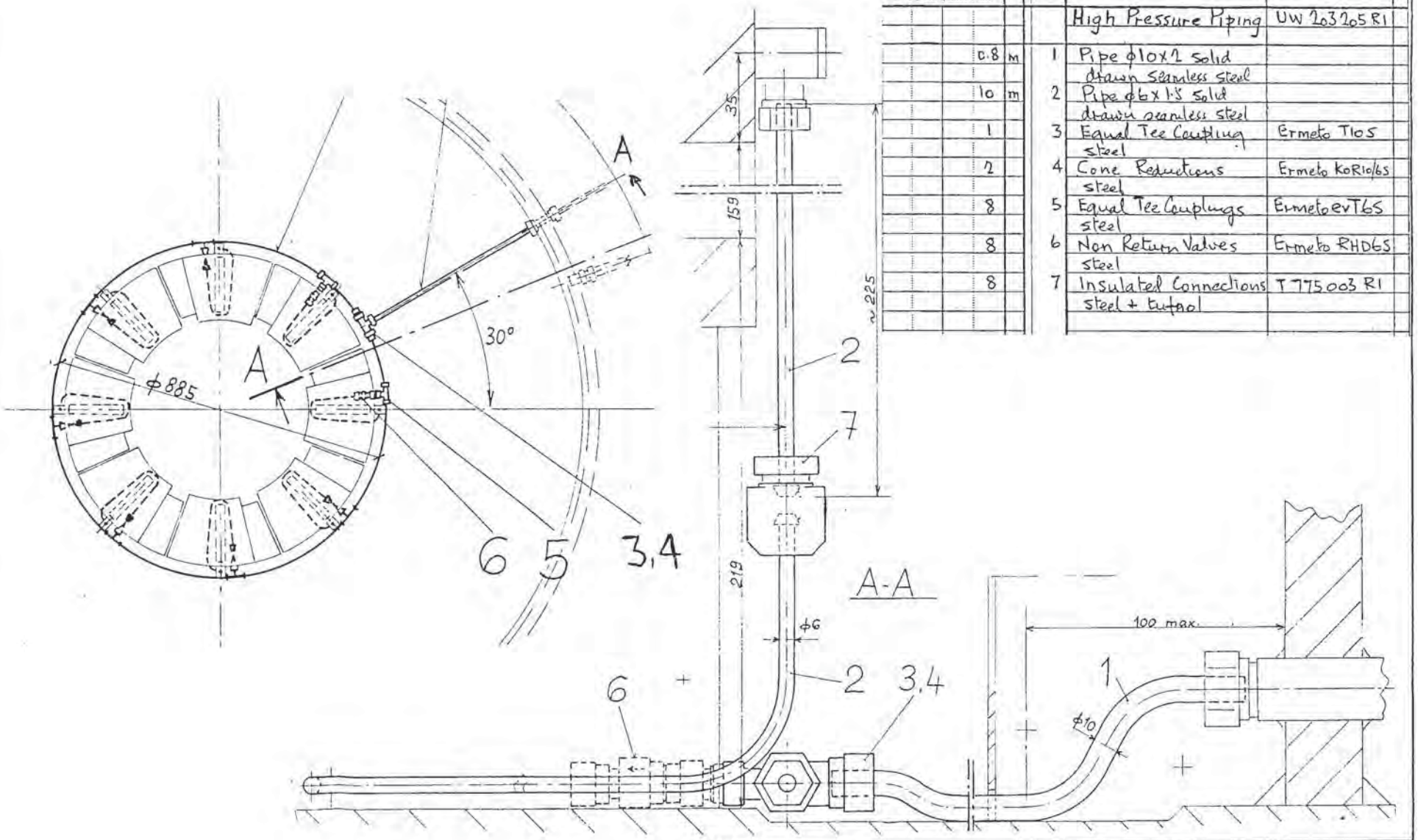
TIBB TECNOMASIO ITALIANO BROWN BOVERI MILANO

THRUST PAD

Additional working on the pad

Doc. Tipo	Formato	Lingua	Foglio N	N. fogli
	A2	I	1	1

UW 202855



Per le rubr.: N. rubr. / Per le pos.: quant./rubr.	U	C	Pos.	Testo	Num. identif.	EC
				High Pressure Piping	UW 203205 R1	
0.8	m		1	Pipe ϕ10x2 solid drawn seamless steel		
10	m		2	Pipe ϕ6x1.5 solid drawn seamless steel		
1			3	Equal Tee Coupling steel	Ermeto T105	
2			4	Cone Reductions steel	Ermeto koR10/6S	
8			5	Equal Tee Couplings steel	Ermeto evT6S	
8			6	Non Return Valves steel	Ermeto RHD6S	
8			7	Insulated Connections steel + tufnol	T 775003 R1	

Mod.	Mod.	Mod.	Scale:	Drawn

FIJI ELECTRICITY AUTHORITY

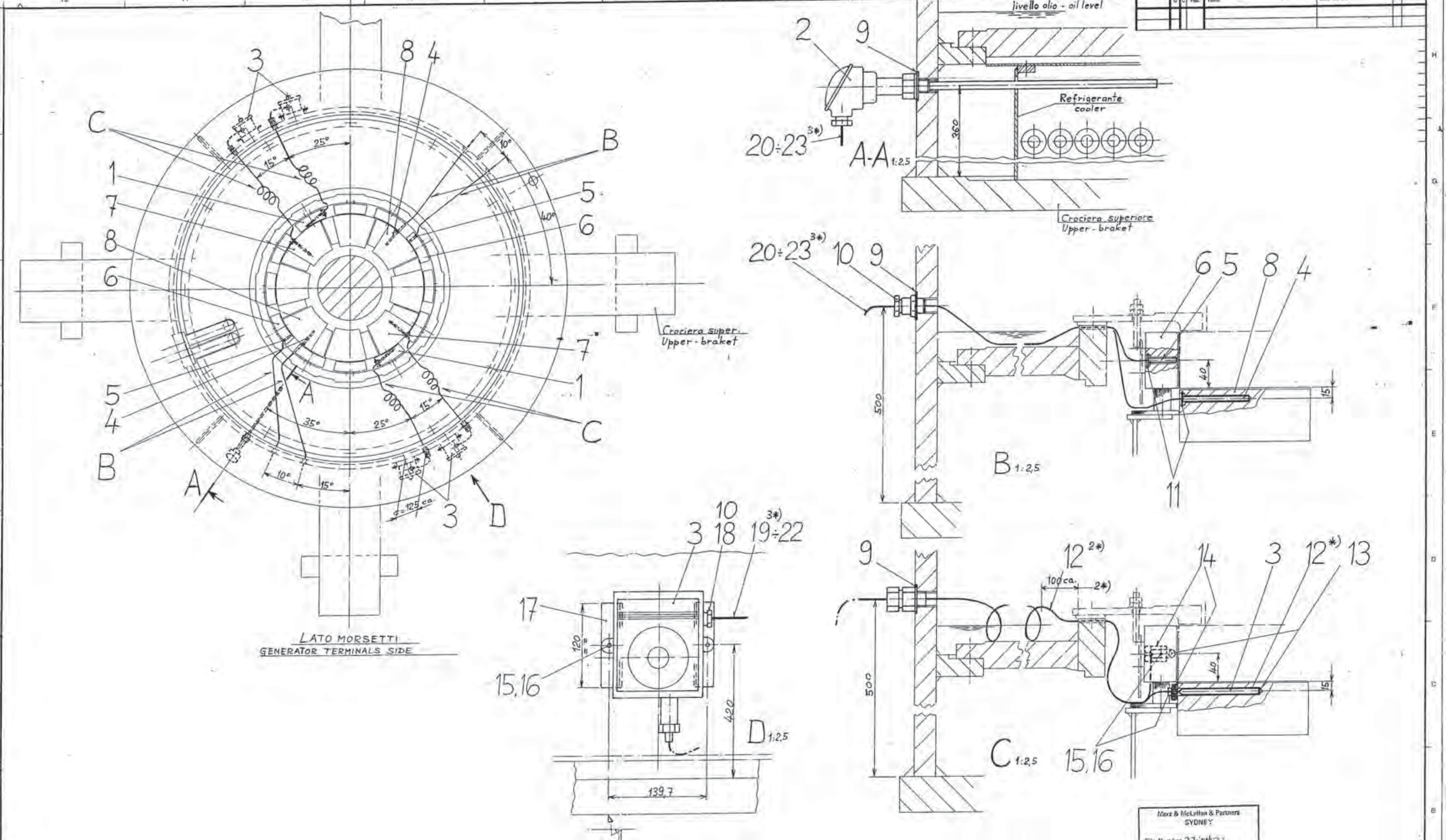
DRAWING Nº

TIBB
TECNOMASIO ITALIANO BROWN BOVERI MILANO

Title:
HIGH PRESSURE PIPING (INSIDE UPPER BRG ASSEMBLY)

REDRAWN FOR INSTRUCTION MANUAL

UW 203205



*) 1 strato non sovrapposto su tutta la lunghezza del bulbo.
1 coat not laid upon all bulb length.

2*) 1 strato 1/2 sovrapposto dalla fine del bulbo fino alla quota indicata.
1 coat half laid upon from the end of bulb to indicate measure.

3*) alla cassetta di centralizzazione sulla carcassa (vedere UW 202986)
to terminal box on the frame (see dwg. UW202986)

Merz & McLellan & Partners
SYDNEY
File Number 27/01/632
Date 27.10.80

Simboli della rugosità secondo GZN 020007

Lavorazione con asportazione di truciolo: all'occorrenza / prescritta / vietata

Classe di rugosità	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4
Max. rugosità Ra (µm)	25	12,5	6,3	3,2	1,6	0,8	0,4	0,2

Scostamenti ammessi per quote senza indicazione di tolleranza secondo HZN 401636 (estratto)

Campi di dimensioni nominali		>0,5 ...3	>3 ...6	>6 ...30	>30 ...120	>120 ...315	>315 ...1000	>1000 ...2000
Scostamenti grado "grossol."		±0,15	±0,2	±0,5	±0,8	±1,2	±2	±3
Scostamenti grado "medio"	X	±0,1	±0,1	±0,2	±0,3	±0,5	±0,8	±1,2

UW103762

W9.01017/W01/1

FIJI ELECTRICITY AUTHORITY
DRAWING Nº 34 M10 159

Emesso 80.10.09 ... Sost. da es. UW103404

Scala 1:10 1:2,5

Senza lista pezzi separ.
Lista pezzi separ. stesso N. ☒
Lista pezzi separ. altro N. ☐

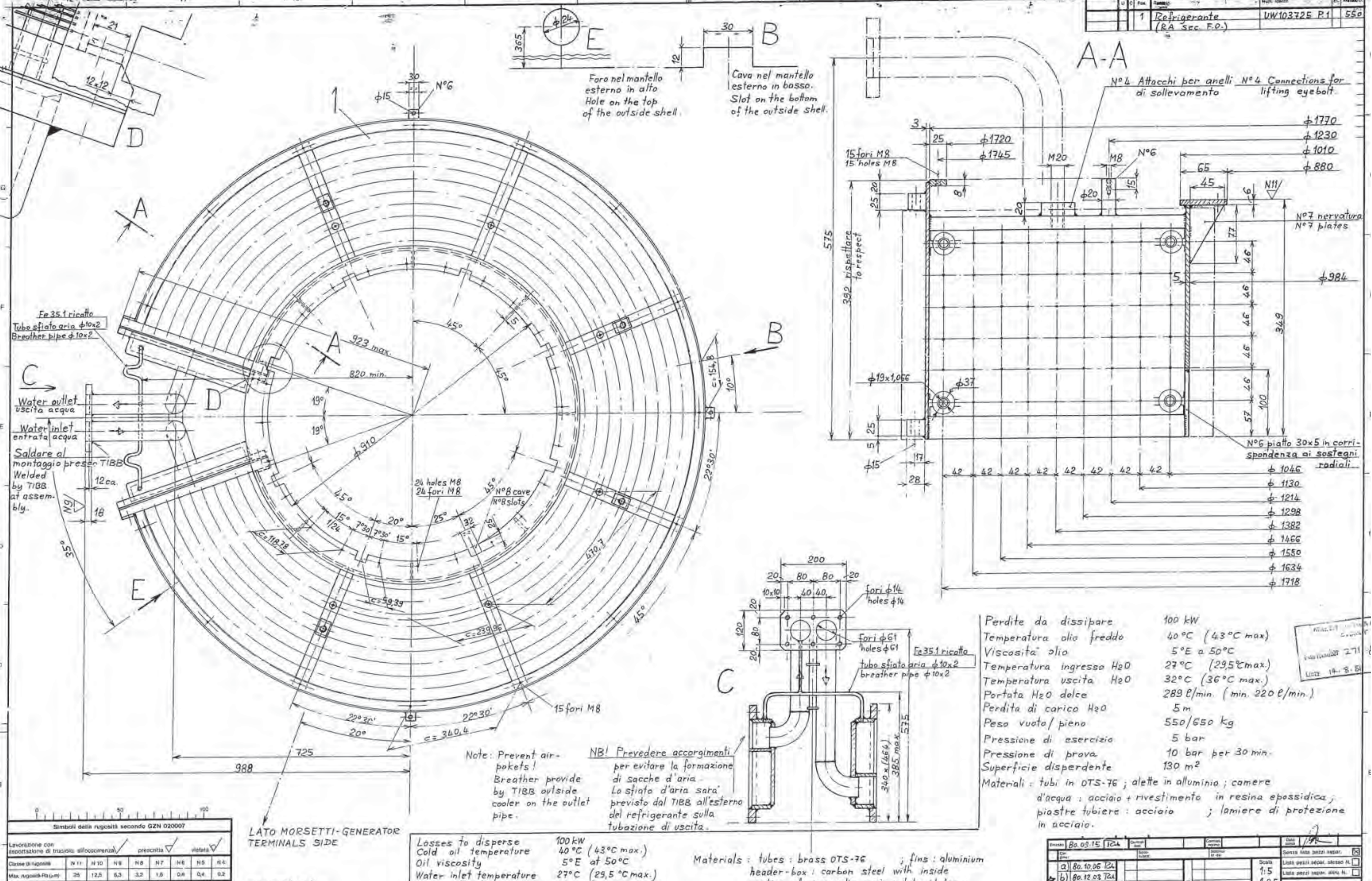
Centro sistem.
Centro respons. 1WTK

Formato A1 | Lingua I-E | Foglio N. 1 | N. fogli 1

TIBB TECNOMASIO ITALIANO BROWN BOVERI MILANO

Titolo: APPLICAZIONE TERMOELEM. (CUSCINETTO GUIDA E SPINTA SUP.)
RESISTENCE TEMPERATURE DETECTORS AND THERMOSTATS DISPOSITION

UW103762



Note: Prevent air-pokets! Breather provide by TIBB outside cooler on the outlet pipe.

NB! Prevedere accorgimenti per evitare la formazione di sacche d'aria. Lo sfiato d'aria sara' previsto dal TIBB all'esterno del refrigerante sulla tubazione di uscita.

Perdite da dissipare	100 kW
Temperatura olio freddo	40°C (43°C max)
Viscosita' olio	5°E a 50°C
Temperatura ingresso H_2O	27°C (29,5°C max.)
Temperatura uscita H_2O	32°C (36°C max.)
Portata H_2O dolce	289 ℓ/min. (min. 220 ℓ/min.)
Perdita di carico H_2O	5 m
Peso vuoto/pieno	550/650 kg
Pressione di esercizio	5 bar
Pressione di prova	10 bar per 30 min.
Superficie disperdente	130 m²

Materiali: tubi in OTS-76; alette in alluminio; camere d'acqua: acciaio + rivestimento in resina epossidica; piastre tubiere: acciaio; lamiere di protezione in acciaio.

Losses to disperse	100 kW
Cold oil temperature	40°C (43°C max.)
Oil viscosity	5°E at 50°C
Water inlet temperature	27°C (29,5°C max.)
Water outlet temperature	32°C (36°C max.)
Quantity of soft water	289 ℓ/min. (min. 220 ℓ/min.)
Loss of pressure water	5 m
Weight cooler empty/full	550/650 kg
Operating pressure	5 bar
Test pressure	10 bar per 30 min.
Heat exchange surface	130 m²

Materials: tubes: brass OTS-76; fins: aluminium; header-box: carbon steel with inside coating of epossydic resin; tube plates: carbon steel; protection plates and plates: carbon steel.

W9.01017/W01/1

Mod. a) Aggiunto tubo sfiato aria 10x2 - mod. partic. E 80.10.06 RL. Up to date 80.10.06

b) Mod. N° Pezzi blocchetti fissag., mater. tubi, alette, piastre tubiere; mod. N° tubi e forma camere acqua - 80.12.03 RL. Up to date 80.12.03

Simboli della rugosità secondo GZN 020007

Scostamenti ammessi per quote senza indicazione di tolleranza secondo HZN 401638 (estratto)

Campi di dimensioni nominali	>0,5 ...3	>3 ...6	>6 ...30	>30 ...120	>120 ...315	>315 ...1000	>1000 ...2000
Scostamenti grado "preciso"	±0,05	±0,05	±0,1	±0,15	±0,2	±0,3	±0,5
Scostamenti grado "medio"	±0,1	±0,1	±0,2	±0,3	±0,5	±0,8	±1,2

1	Refrigerante (RA Sec. F.O.)	UW103725 P1	550

Titolo: REFRIGERANTE CUSCINET. DI SPINTA E GUIDA — COMBINED THRUST AND GUIDE BEARING COOLER

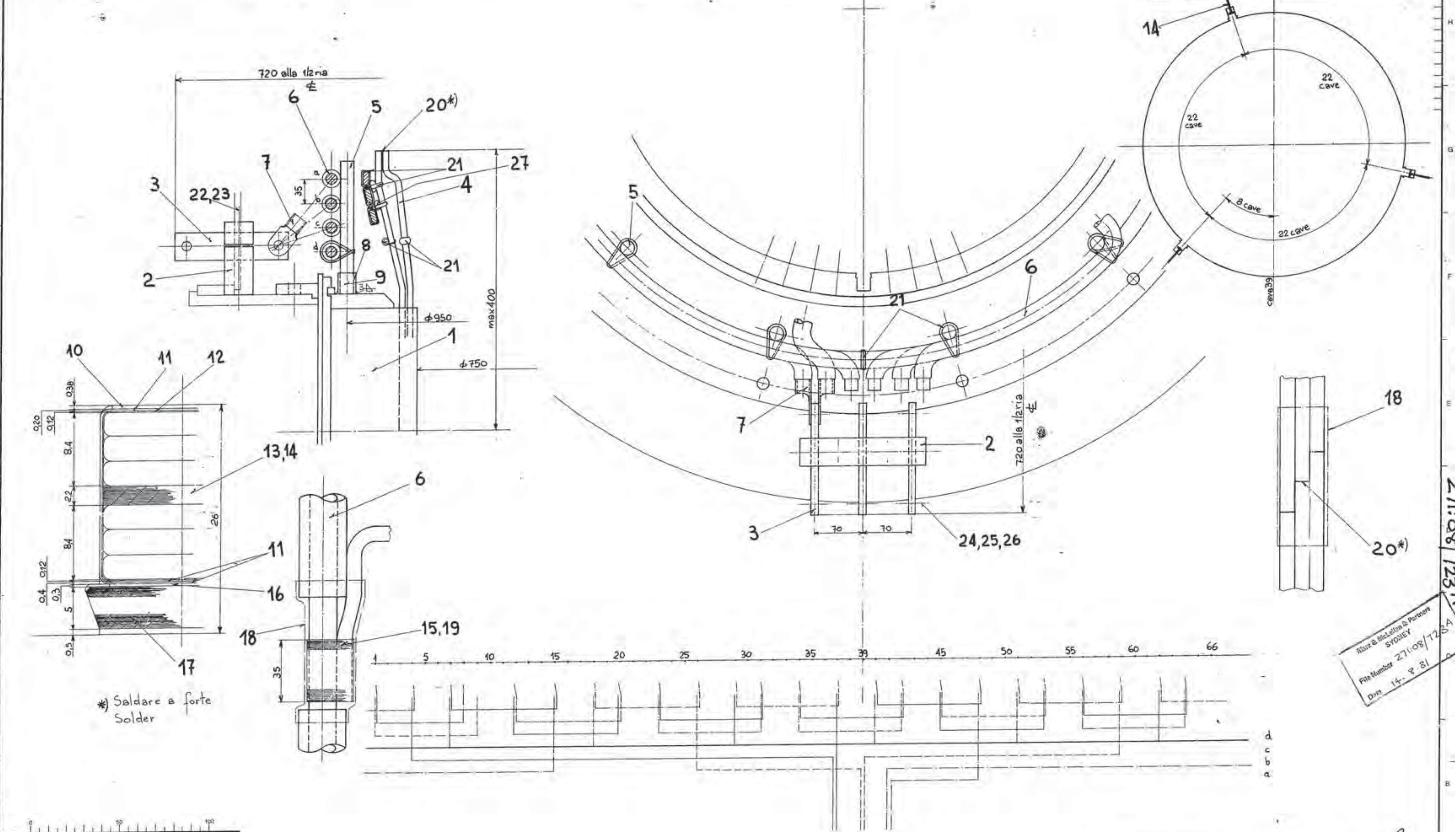
TIBB

Scala 1:5 / 1:2,5 — Formato A1 — Lingua I-E — Foglio N. 1 — N. fogli 1

Emesso 80.03.15 — a) 80.10.06 — b) 80.12.03

FIJI ELECTRICITY AUTHORITY — DRAWING N° 34 M10 155

UW103725



*) Saldare a forte
Solder

Simboli della rugosità secondo GZN 026007

Lavorazione con asportazione di truciolo: all'occorrenza		prescritta			vietata		
Classe di rugosità	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4
Max. rugosità Ra (μm)	25	12,5	6,3	3,2	1,6	0,8	0,4	0,2

Scostamenti ammessi per quote senza indicazione di tolleranza secondo HZN 401638 (estratto)

Campi di dimensioni nominali		> 0,5 … 3	> 3 … 6	> 6 … 30	> 30 … 120	> 120 … 315	> 315 … 1000	> 1000 … 2000
Scostamenti grado "grosso"		± 0,15	± 0,2	± 0,5	± 0,8	± 1,2	± 2	± 3
Scostamenti grado "medio"	X	± 0,1	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2

UW103826

W9.38002/W38/1

Mod.
a)
Aggiunta quota
"max 400"
80.12.23 Cap.

FIJI ELECTRICITY AUTHORITY
DRAWING Nº 34 M10 162

Emesso 80.10.27 Cap.
a 80.12.23 Cap.

Scala 1:1 1:25 5:1

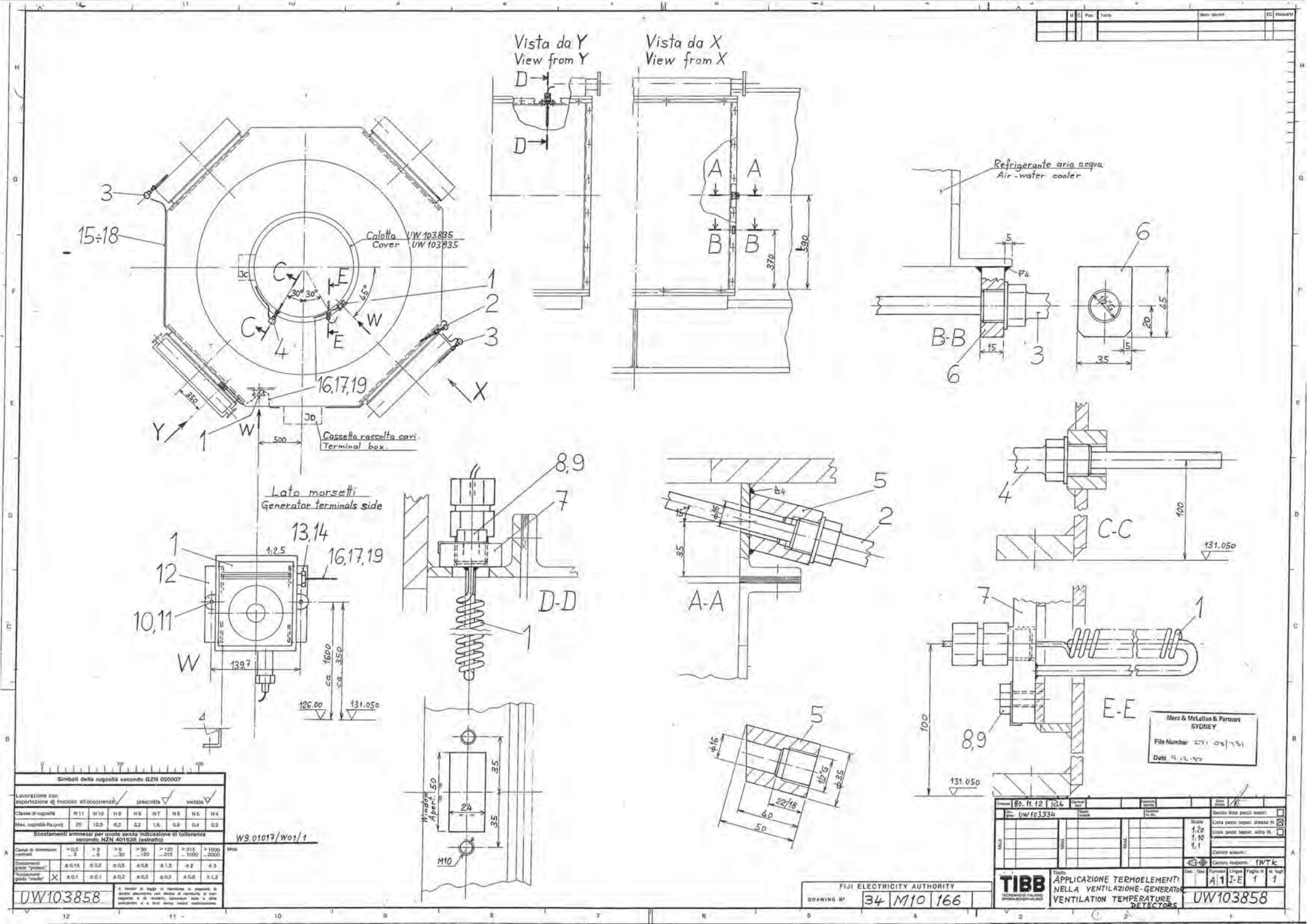
Senza lista pezzi separ.
Lista pezzi separ. stesso N. ☒
Lista pezzi separ. altro N.

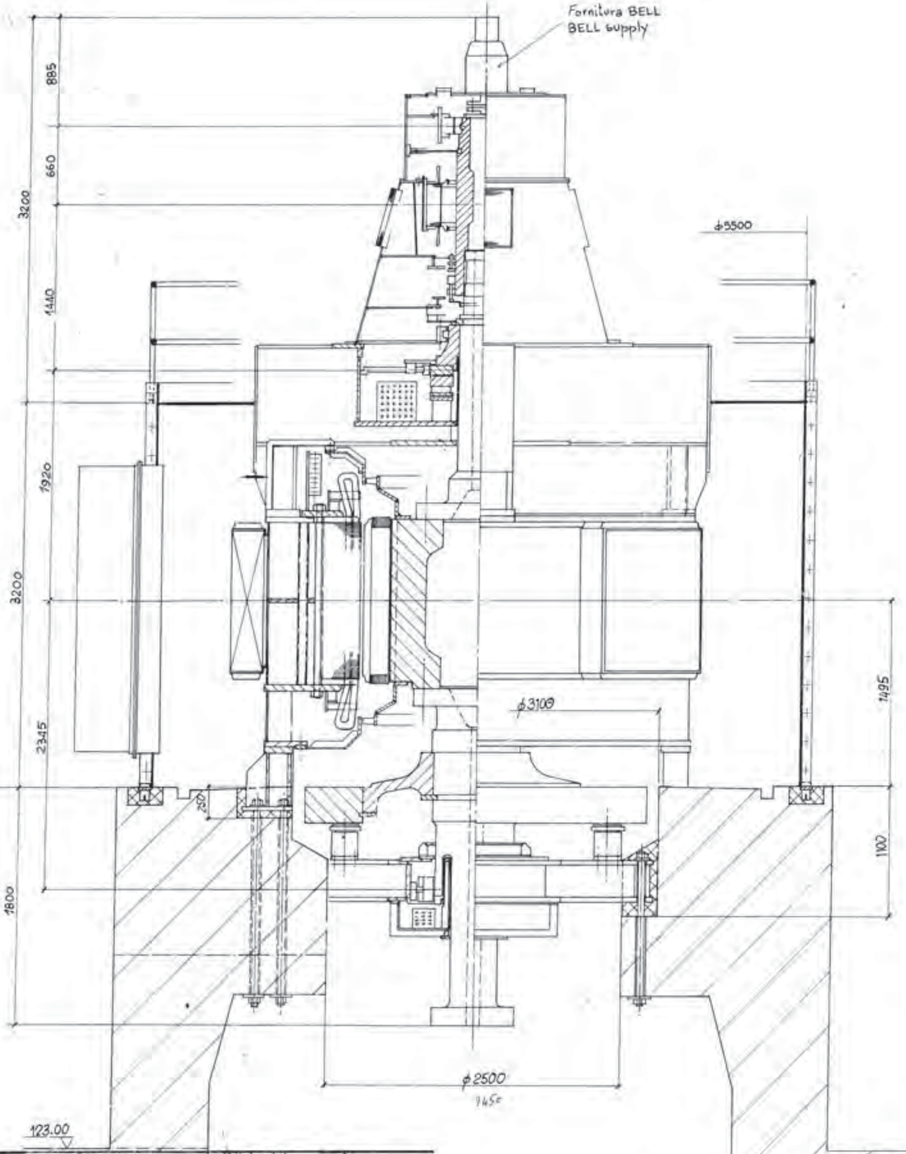
TIBB
Titolo: Statore con avvolgimento
Exciter Stator with winding

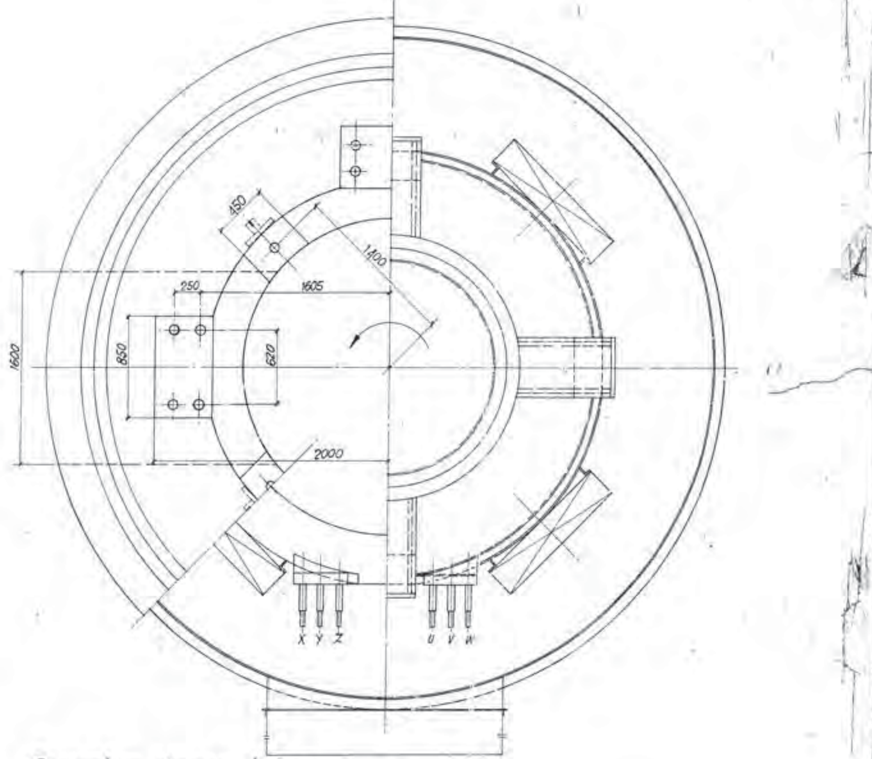
Formato 1 | Lingua I-E | Foglio N. 1 | N. fogli 1

UW103826

Nilsen & McLellan & Partners SYDNEY
File Number 271:08/723A
Date 14.8.81


Vista da Y
View from Y
Vista da X
View from X
Refrigerante aria acqua
Air - water cooler
Calotta UW 103835
Cover UW 103835
Cassetta raccolta cavi.
Terminal box.
Lato morsetti
Generator terminals side
15÷18
16,17,19
13,14
10,11
8,9
B-B
C-C
D-D
A-A
E-E
1:2,5
126.00
131.050
Merz & McLellan & Partners
SYDNEY
File Number 271 08/731
Date 9.12.93
FIJI ELECTRICITY AUTHORITY
DRAWING Nº 34 M10 166
UW103858
W9.01017/Wo1/1
APPLICAZIONE TERMOELEMENTI
NELLA VENTILAZIONE-GENERATORE
VENTILATION TEMPERATURE DETECTORS
TIBB





Generatore sincrono trifase
Threephase synchronous generator

24,5 MVA
11 KV
cos φ 0,85 – 50 Hz
N° giri 750 rpm — Velocità di fuga 1336 rpm
Speed — Runaway speed

FIJI ELECTRICITY AUTHORITY - MONASAVU

271:08/164 E

FEA DRG № 34-M11-059

Mod.	Data
a	79.04.30
b	79.05.15
c	79.09.26
d	80.09.23
e	81.04.16

Scala 1:20

TIBB

Assieme di disposizione
Layout

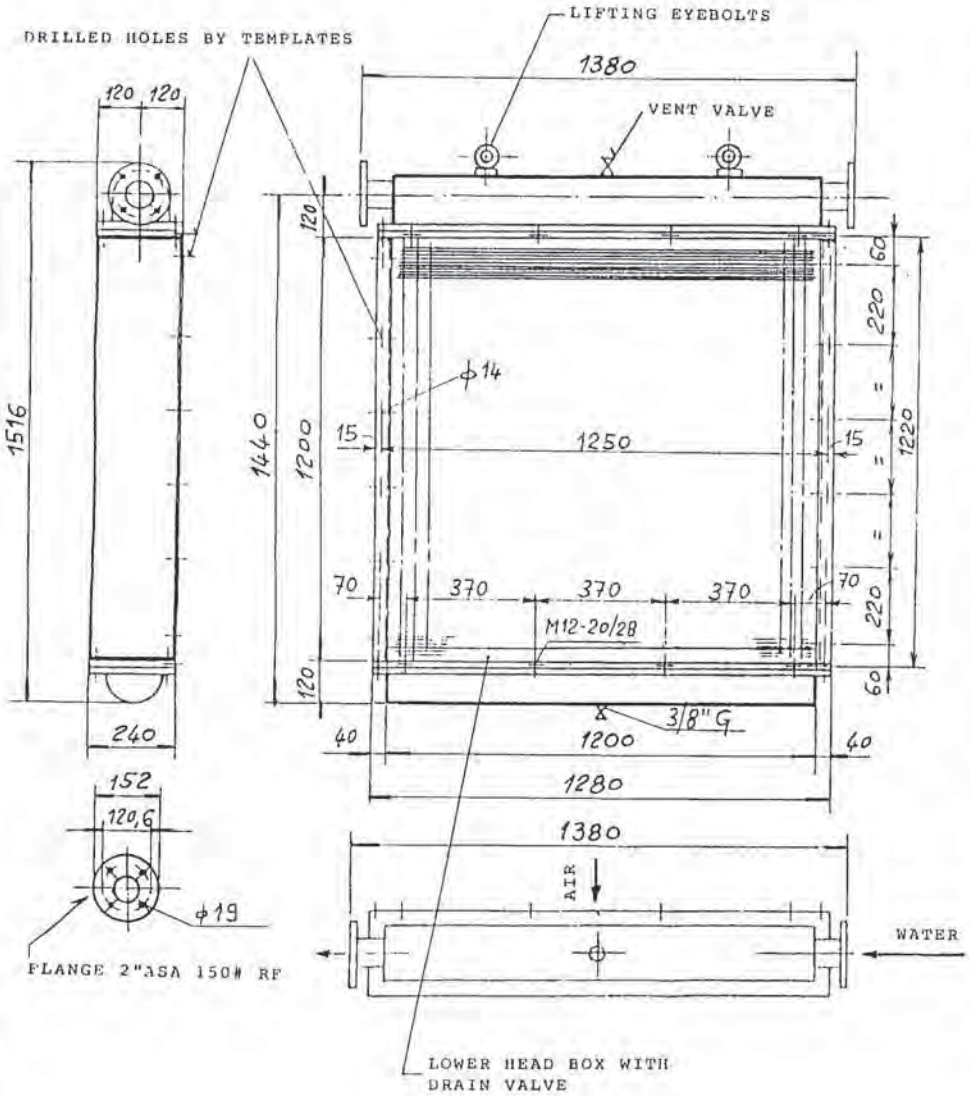
1 I·E 1 1

UW 103175

Mod. a) Upto date foundations 79.04.30
b) Modified foundation and added terminals denomination 79.05.15
c) Upto date rotor 79.09.26
d) Upto date 80.09.23
e) Upto date 81.04.16

UW 103175

MICROBOX



MATERIALS

FINNED TUBES	:	19.05 Ø x 1.245 THK - AL BRASS; FIN Ø 37 - COPPER
TUBE PLATES	:	CARBON STEEL.
HEADER BOXES	:	CARBON STEEL WITH INSIDE COATING OF RESIN "SAEKAPHEN"

DESIGN PERFORMANCE AT TAILRACE WATER TEMPERATURE OF 25°C		RATED 100% LOAD AND 2 TAILRACE WATER/WATER COOLERS	VAR 1 MAX. LOAD WITH 1 GENERATOR AIR COOLER OUT OF SERVICE	VAR 2 MAX. LOAD WITH 1 TAILRACE WATER/WATER COOLER OUT OF SERVICE
HEAT LOSSES PER COOLER	kW	120	120	90
QUANTITY OF INTERNAL RECIRCULATED WATER	l/min	226	248	172
INTERNAL RECIRCULATED WATER				
INLET TEMPERATURE	°C	27.1	26.6	29.6
OUTLET TEMPERATURE	°C	34.7	33.5	37.1
QUANTITY OF AIR (I.E., GENERATOR)	m^3/sec	4.625	6.17	4.625
AIR INLET TEMPERATURE	°C	62.7	58.2	56.8
AIR OUTLET TEMPERATURE	°C	39	40.5	39.2

INTERNAL PRESSURE LOSS (WATER)	0.6 bar max
EXTERNAL PRESSURE LOSS (AIR)	2.5 kPa max
GENERATOR AIR TO WATER COOLER SURFACE	96.7 m^2
OPERATING PRESSURE WATER SIDE	5 bar
TEST PRESSURE AIR SIDE	.375 kPa
HYDROSTATIC TEST PRESSURE	10 bar for 30 min
COOLER WEIGHT: EMPTY	440 kg
FULL	600 kg

Mod.	Mod.	Mod.	Scale:	Drawn

FIJI ELECTRICITY AUTHORITY

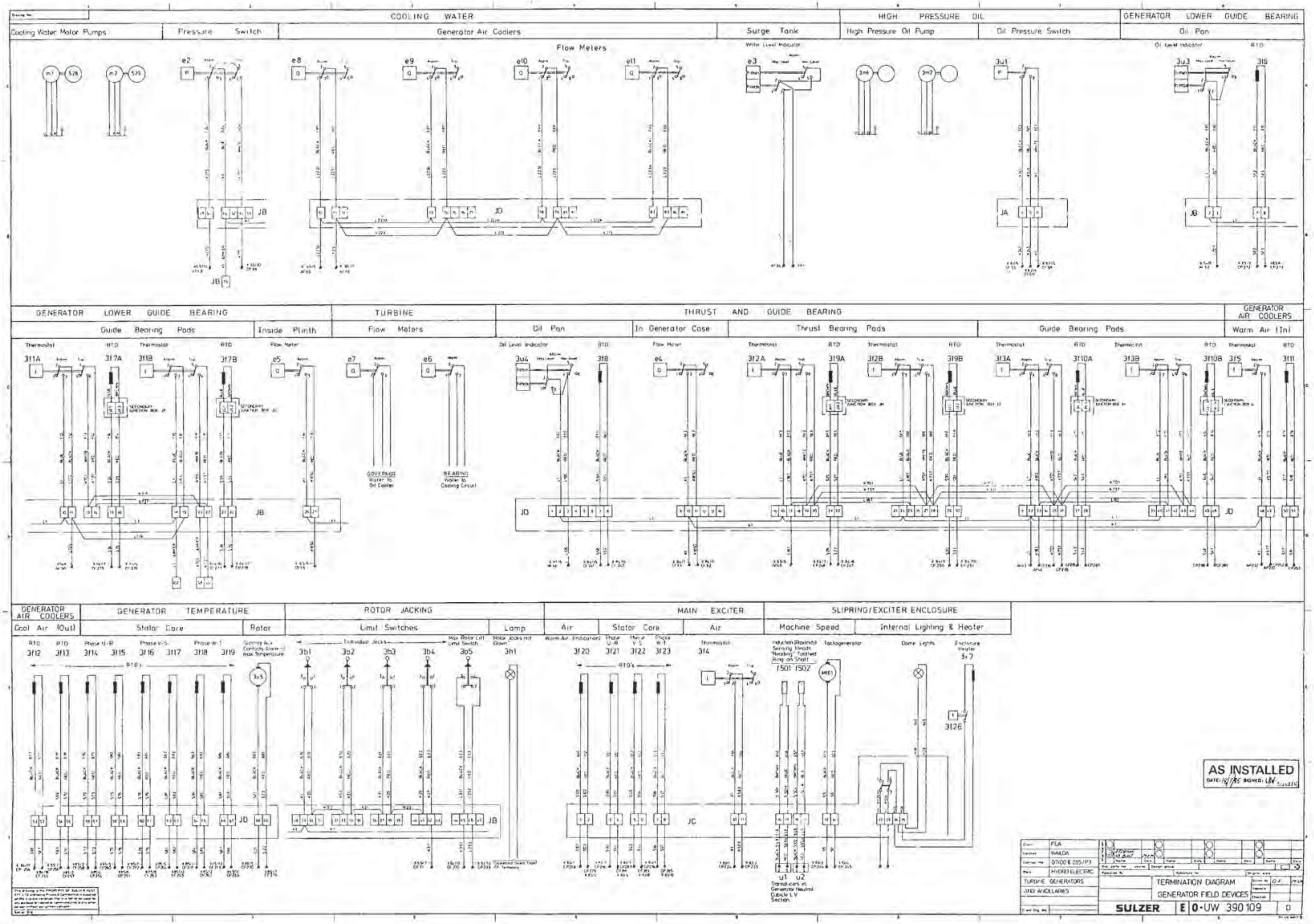
DRAWING Nº

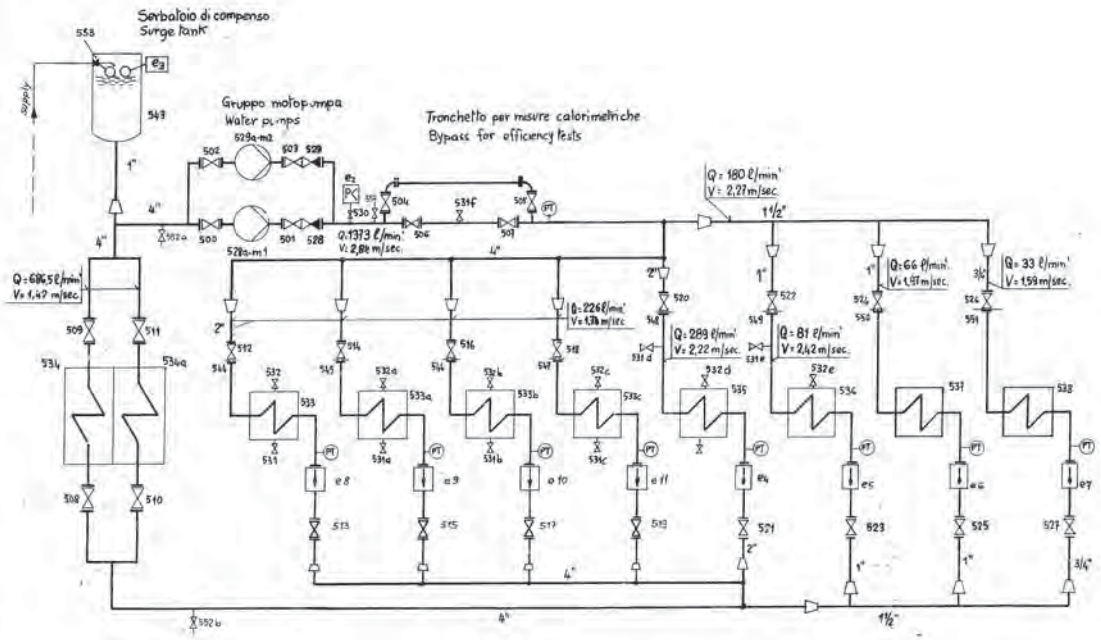
TIBB
TECNOMASIO ITALIANO BROWN BOVERI MILANO

Title:
GENERATOR
AIR-WATER COOLER

REDRAWN for INSTRUCTION MANUAL

UW 302 516


COOLING WATER
Cooling Water Motor Pumps
Pressure Switch
Generator Air Coolers
Flow Meters
Surge Tank
HIGH PRESSURE OIL
High Pressure Oil Pump
Oil Pressure Switch
GENERATOR LOWER GUIDE BEARING
Oil Pan
GENERATOR LOWER GUIDE BEARING
Guide Bearing Pods
Inside Plinth
TURBINE
Flow Meters
GOVERNING Water to Oil Cooler
BEARING Water to Cooling Circuit
THRUST AND GUIDE BEARING
Oil Pan
In Generator Case
Thrust Bearing Pads
Guide Bearing Pads
GENERATOR AIR COOLERS
Warm Air (In)
GENERATOR AIR COOLERS
Cool Air (Out)
GENERATOR TEMPERATURE
Stator Core
Rotor
ROTOR JACKING
Limit Switches
Lamp
MAIN EXCITER
Air
Stator Core
Air
SLIPRING/EXCITER ENCLOSURE
Machine Speed
Internal Lighting & Heater
Dome Lights
Enclosure Heater
u1 u2
Transducers in Generator Neutral Cubicle LV Section
AS INSTALLED
TURBINE GENERATORS
AND ANCILLARIES
HYDRO ELECTRIC
TERMINATION DIAGRAM
GENERATOR FIELD DEVICES
SULZER
E 0-UW 390109
D



504, 505	Valvole a saracinesca	3"	Gate Valves	3"
500÷503, 506÷511	Valvole a saracinesca	4"	Gate valves	4"
512 ÷ 521	Valvole a saracinesca	2"	Gate valves	2"
522 ÷ 525	Valvole a saracinesca	1"	Gate valves	1"
526, 527	Valvole a saracinesca	3/4"	Gate valves	3/4"
528, 529	Valvole di ritenuta	4"	No return valves	4"
530, 531 f	Valvola intercettazione	1/2"	Interception valves	1/2"
531÷531e	Valvole di scarico	3/8"	Drainage valves	
532÷532b	Prese di pressione	1/2"	Pressure tapping	
532÷532e	Valvola di sfiato	3/8"	Breather valves	
533÷533c	Refrigeranti aria-acqua		Generator air-water coolers	
534, 534a	Refrigeranti acqua-acqua		Water-water coolers	
535	Refrigerante olio sopporto superiore		Generator upper bearing oil cooler	
536	Refrigerante olio sopporto inferiore		Generator lower bearing oil cooler	
537	Cuscinetto turbina		Turbine bearing oil cooler	
538	Regolatore turbina		Turbine governor oil cooler	
e4	Indicatore di flusso con contatti		Liquid flow monitor with switch	
e5÷e7	Indicatore di flusso con contatti		Liquid flow monitor with switch	
e8÷e11	Misuratore di flusso con contatti		Liquid flow monitor with switch	
e2	Trasmettitore di pressione		Pressure transmitter	
e3	Interruttore di livello		Low level alarm switch	
543	Serbatoio di compenso		Surge tank	
544÷551	Diaframmi tarati		Calibration orifice	
528a-m1	Gruppo motopompa		Cooling waterpump	
529a-m2	Gruppo motopompa		Cooling waterpump	
(PT)	Pozzetto per prove di temperatura		Pockets for Th.	
553	Valvola a galleggiante	3/4"	Float valve	3/4"

The valves Pos. 505, 507 are drived by chain

Ord. W9.01097/011

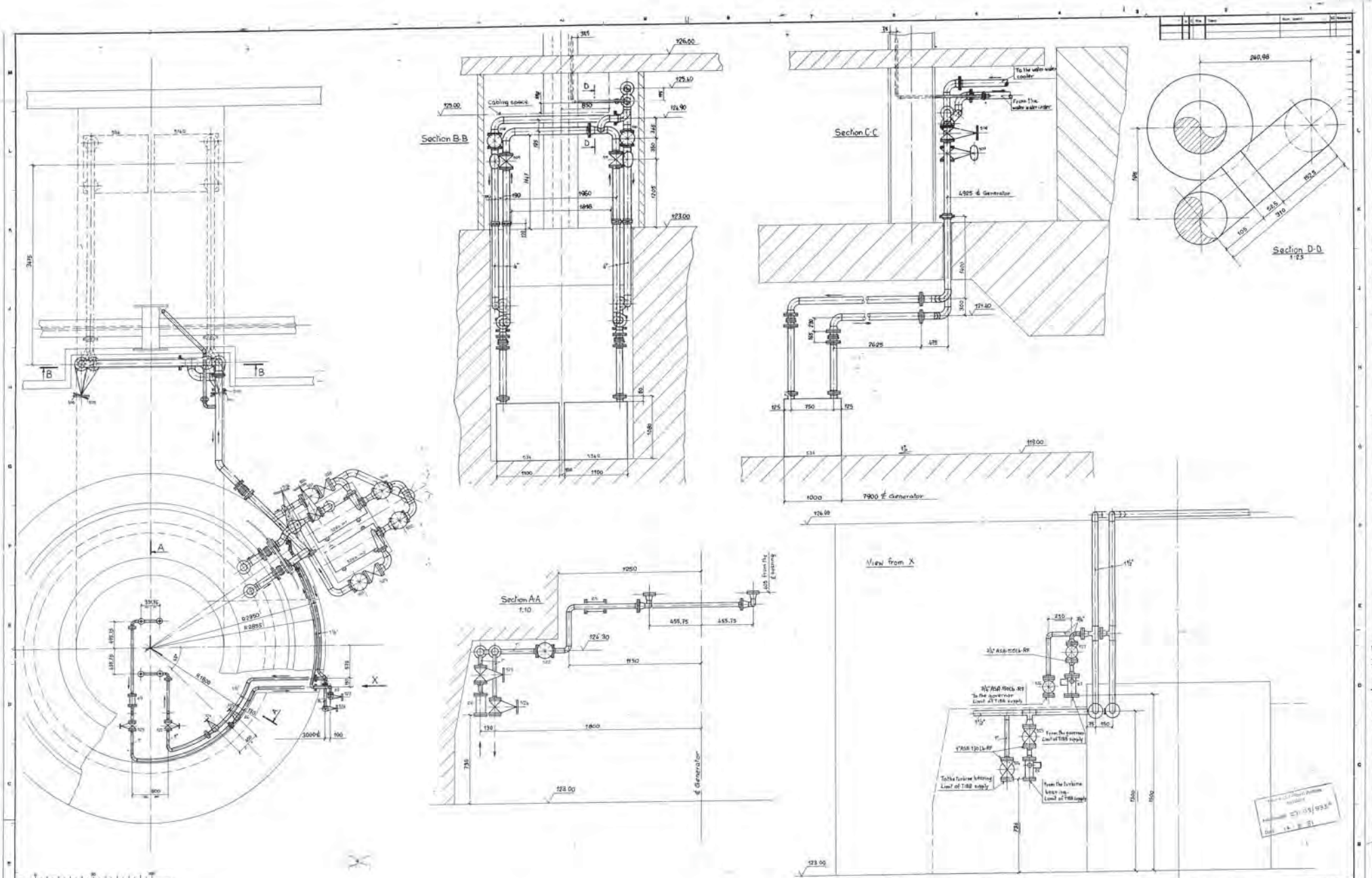
UW103517

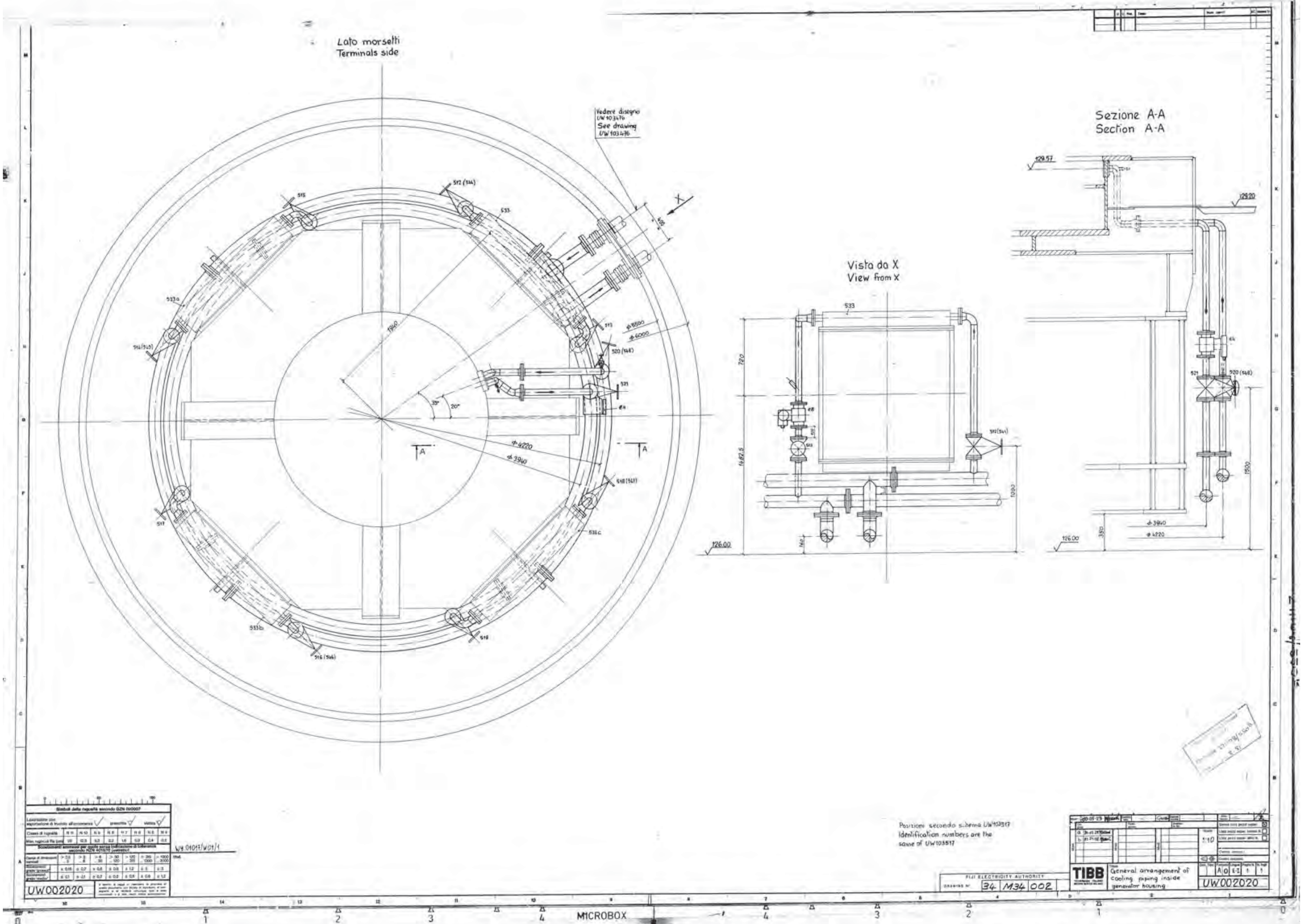
FIJI ELECTRICITY AUTHORITY
DRAWING No 34 M31 001

TIBB
Schema impianto refriger.
Schematic cooling water system
UW103517
A1 1-E 1 1

MICROBOX

27108/3589


Section B-B
Section C-C
Section D-D
1:2.5
Section A-A
1:10
View from X
Cooling space
To the water water cooler
From the water water cooler
4925 ℄ Generator
7900 ℄ Generator
℄ Generator
To the turbine bearing Limit of TIBB supply
From the turbine bearing Limit of TIBB supply
To the governor Limit of TIBB supply
From the governor Limit of TIBB supply
Identification numbers are the same of the UW103511
UW 001995
FIJI ELECTRICITY AUTHORITY
DRAWING NO 34 N34 001
TIBB
General arrangement of cooling water pumps and piping below 91.195
UW 001995
MICROBOX


Lato morsetti
Terminals side
Vedere disegno UW103476
See drawing UW103476
Sezione A-A
Section A-A
Vista da X
View from X
533
533a
533b
533c
512 (514)
515
513
520 (548)
521
516 (546)
517
518 (547)
519
510 (541)
64
68
ф 5500
ф 6000
ф 4220
ф 3960
1960
20°
35°
129.57
129.20
126.00
720
1482.5
1000
1500
380
140
Posizioni secondo schema UW103517
Identification numbers are the same of UW103517
FIJI ELECTRICITY AUTHORITY
34 M34 002
TIBB
General arrangement of cooling piping inside generator housing
1:10
UW002020
MICROBOX

Appendix B Common Requirements Specification

Fiji Electricity Authority

Wailoa Mid-Life Refurbishment Project

Common Requirements

June 2016

Fiji Electricity Authority

Wailoa Mid-Life Refurbishment Project

Common Requirements

Contents

1 Design Requirements

1.1 Design Responsibility

The Contractor shall assume full responsibility for a coordinated and adequate design of all equipment specified and shall ensure that such equipment conforms to the best engineering practice for the operating conditions specified. When requested by the Engineer, the Contractor shall furnish complete information as to the maximum stresses and other criteria used in the design. All equipment shall be proportioned and arranged to fit with proper clearances into the nominated spaces.

1.2 Project Procedures

The Contractor shall issue a set of Project Procedures within 28 days from the Commencement Date for Engineer's review and approval. Such document shall give the procedures which shall govern the relationship between Employer and Contractor, document distribution, lines of communication (including contact information), responsibility of project participants, etc.

1.3 Submittals

The following drawings and document listing is intended to summarize the information and data to be submitted by the Contractor to the Engineer. In the case of differences between this list and the specific submittal descriptions of the Employer's Requirements, or the Particular Conditions of Contract, the specific descriptions or particular conditions shall govern.

Table 1.1

Document	Submittal Schedule	Submitted for
A. Basic Design Drawings		
All documents as detailed in the "Basic Design" section of the Technical Specification.	Note 2	Review/Approval
B. Detailed Design		
All documents as detailed in the "Detailed Design" section of the Technical Specification.	Note 2	Review/Approval
C. Other Documents		
Quality control plan	Within 10 days of Commencement	Review/Approval
Contractor progress reports	Monthly	
Materials test certificates	As received.	Info/Record
QA/QC procedures	Note 2	Review/Approval
Shop test/inspection reports		Review/Approval

Document	Submittal Schedule	Submitted for
	On completion of each test/inspection	
Operating and Maintenance Manuals	Note 3	Review/Approval
Field Commissioning Procedures	Note 4	Review/Approval
Shop drawings	Note 2	Info/Record
As-Built design drawings	Note 2	Info/Record
Recommended spare parts and maintenance equipment list	Note 2	Review

Notes:

1. Submittals

   a. "Info/Record" refers to documentation that normally will not be reviewed by Engineer during the design phase but is required for the testing, commissioning and operation phase.
   b. "Review" refers to documents that Engineer will receive and comment on during the design, construction or testing, commissioning and testing phase, as applicable.
   c. "Approval" refers to documents Engineer shall approve or give acceptance as set forth in the Contract.
   d. If documents are required earlier to support Engineer related activities such as: permitting interface with other Employer contractors' activities, etc., Contractor shall use all reasonable efforts to support these requirements.

2. Design Drawings and Documents

   a. The Basic Design provided with the Tender shall be updated and issued as follows:
      (1) Issue for comments from the Engineer
      (2) Engineer comment period is 14 days
      (3) Incorporate comments and issue for final review within 14 days
      (4) Engineer's final review period is 14 days
      (5) Basic Design issued within 14 days.

   b. Detailed Design to be issued as follows:
      (1) Issue for comments from the Engineer
      (2) Engineer comment period is 14 days
      (3) Incorporate comments and issue for Construction
      (4) Engineer will comment again if necessary and the Contractor will revise the document if required.

   c. Design drawings and documents shall be transmitted to Engineer upon issuance of the drawing/document, or any revision thereof, or when "Issued for Construction" or "issued for Manufacture".

   d. Shop drawings and documents to be transmitted to Engineer for "Info/Record" shall be transmitted to Engineer within 1 month after shipment of the plant to which the Shop drawing relates.

   e. As Built or As Constructed drawings and documents to be transmitted to Engineer for "Info/Record" shall be transmitted to Engineer on within 2 weeks after shipment of the plant to which the As Built drawing relates or within one month after construction is completed. Red pen markups of all

construction drawings showing any site modifications shall be retained on site until such time as the As Constructed records have been delivered.

3. Operating and Maintenance manuals shall be provided 4 weeks prior to ex works shipment of the plant to which the Operating and Maintenance manuals relates.
4. Field Commissioning Procedures shall be provided 3 months prior to the field testing and commissioning of the plant to which the Field Commissioning Procedures relates.

1.3.1 Drawing Standards

All drawings shall be prepared in accordance with ISO standards, and shall be based on the "A" series paper sizes as defined in ISO216.

Electrical drawings shall use the IEC symbol set as defined in IEC 60617.

P&ID drawings shall use the symbol set defined in the Instrument Society of America standard S5.1.

Electronic master files of all drawings shall be provided in Autocad DWG format. Each dwg file shall only contain one drawing sheet and shall have a unique file number that matches the number on the drawing sheet. The electronic file shall be saved such that, upon opening, the full drawing is depicted on the screen and the "Print Extents" command will print the entire drawing correctly aligned on the paper.

All drawings shall include the following:-

- Drawing title.
- Logo for the Employer, Engineer and Contractor.
- Original drawing size.
- Revision Index.
- Quality control verification for checked and approved.
- Space for Employers Approval.
- Drawing number using the Employers drawing numbering system.

All modifications made to a drawing shall be "clouded" and marked with the revision identification. Previous revision clouding shall be removed.

1.3.2 Outline Drawings

Outline drawings shall be drawn to scale and denoted with critical or major dimensions. Drawings shall include estimated weights, external forces, anchoring details and overall dimensions and information on installation requirements for the equipment.

1.3.3 Detail Drawings

Detail drawings shall consist of general assembly Drawings, subassembly Drawings and details to demonstrate fully that all parts will conform to the provisions and intent of the Employer's Requirements and to the requirements of their installation, operation and maintenance.

1.3.4 Line Diagrams

- Electrical Single line diagrams showing the power connections, location of instrument and control transformers, and connections to transducers, meters, relays and instruments.
- Single line relay diagrams. Expanded single line diagrams showing all protective relay elements and tripping paths.
- Process and Instrumentation Diagrams (P&IDs) for all systems.

1.3.5 Schematic/Elementary Diagrams

Diagrams shall demonstrate the operation of the supplied control equipment. They shall include:

- Electrical schematic drawings showing each individual component, terminal, interconnecting wiring, associated terminal, conductor and cable identification; protective device ratings and settings; voltage levels.

Electrical schematic drawings shall be ladder style drawing to DIN standards, including an 'assembled form' depiction of each element with references identifying the drawing sheet on which each terminal is used.

1.3.6 Wiring Diagrams

Diagrams shall show the point-to-point interconnections of the control and power equipment. Control devices and terminal blocks shall be shown in their correct relative positions. One side of the terminal blocks shall be clearly identified for external wiring connections and shall be free of any manufacturer's wiring. Control devices and terminal blocks shall be identified in accordance with schematic/elementary diagrams.

1.3.7 Panel Layouts

Equipment and nameplates mounted on and within control cabinets and switchboards shall be shown. Diagrams shall be drawn to scale.

1.3.8 Nameplate Schedules, Meter Scales, Engravings and Switch Handles

Schedules for all front-of-panel devices and equipment shall be provided. Nameplate schedules shall include dimensions and lettering size. Scale markings for meters and other indicating instruments shall be shown. Escutcheon plate and legend plate engravings and type and color of switch handles shall be shown.

1.3.9 Design Calculations

The design calculations shall define the design approach, assumptions, criteria used and the calculated results in sufficient detail to demonstrate that the equipment meets the specified requirements and to provide adequate information for trouble-shooting of the equipment.

1.3.10 Bills of Material

A list of equipment shall be submitted for each major assembly or sub-assembly and shall include the names of manufacturers of articles and auxiliary equipment to be incorporated in the work, together with description, part number, ratings, performance characteristics and other significant information as necessary to allow the Employer to obtain replacement parts. A separate list of equipment shall be provided for each printed circuit board and sub-assembly incorporated into the work, identifying the individual components mounted on the board. Bills of Material shall be provided listing the spare parts, special tools and maintenance equipment.

1.3.11 Cable Schedules

Tabulations showing the routing of all cable and wire used for power, control and instrumentation circuits shall be provided. Cable tabulations shall be prepared showing the type, size and number of conductors in each cable. Each cable shall be given a unique cable identifier. The cable tabulations shall list the equipment to which each cable is connected (From/To) and the cable tray in which it is routed.

1.3.12 Pipe Schedules

Tabulations showing the routing of all piping shall be provided. Pipe tabulations shall be prepared showing the material, size, pressure and conveyed material of each pipe. Each pipe shall be given a unique pipe identifier. The pipe tabulations shall list the equipment to which each pipe is connected (From/To) and the pipe rack in which it is routed.

1.3.13 Functional Block Diagrams

1.3.14 Block diagrams shall be provided that show the functional configuration of the main components of a system including the communication network and paths interconnecting them. The functional block diagram shall be presented in a manner that conveys the functionality of the system. Termination Drawings/Schedules

All terminations of power, control and instrumentation cable external to an electrical component, panel or cabinet shall be shown either on termination drawings or on schedules. Information shall include the terminal block designation, cable identifier, cable characteristics (i.e., size, number conductors/pairs/triads, shielding) conductor identification (e.g., number, color), number of spare conductors and to where the other end of the cable is routed (with references).

1.3.15 Logic Diagrams

1.3.15.1 General

A complete set of logic diagrams describing the software used in microprocessor-based controllers shall be provided. The logic diagrams shall be provided as follows:

- Analog Control Loops. These diagrams shall be provided in accordance with ISA standard format.

- Sequencing Controls. Controls used for sequencing logic shall be provided in Boolean or ladder-type format.

Logic diagrams shall be drawing in accordance with IEC 61131-3.

1.3.15.2 Software

Software updates or enhancements shall be supplied to the Employer at no charge within two (2) years after the last delivery of the equipment. After this period, updates shall be made available to the Employer at a negotiated fee.

1.3.16 Erection Schedule

A detailed erection schedule shall be prepared and submitted to the Engineer showing the estimated time needed for installation and listing the type and number of personnel and tools required by the Contractor. The schedule shall be submitted not later than two (2) months prior to delivery of the first piece of equipment. The schedule shall include the time required for field erection, installation, check-out, start-up, initial operation, testing and test run.

1.3.17 Instructions

1.3.17.1 General

The Contractor shall submit written detailed instructions for factory assembly and testing; handling and storage; installation, operating and maintenance and field commissioning procedures of check-out, start-up, initial operation, testing and test run for each item of equipment. The instructions shall be submitted as early as possible so that final reviewed copies can be made available to the field for use in planning their work well in advance of actual installation and operation. After review, ten (10) complete, durable bound copies of the final instructions shall be furnished.

1.3.17.2 Shop Assembly and Testing Procedure

A step-by-step procedure shall be submitted outlining the details of the checks to be made before and after factory assembly and testing of the equipment to demonstrate that the requirements of these Employer's Requirements and other parts of the Contract have been fulfilled. The factory assembly and testing procedure shall be submitted in a tabular form itemizing each test, indicating the results expected in accordance with the design and leaving space for the actual observation during assembly and testing. The test procedures shall include test values to be used, maximum/minimum acceptable test results and reference to accepted industry standards. The limitations, if any, of the factory tests shall be fully explained and shall be approved by the Engineer.

1.3.17.3 Handling and Storage Instructions

Detailed instructions, with illustrations, diagrams and weights, for handling, storage and care of equipment at the site shall be submitted. The instructions shall include:

- Identification of parts requiring special outdoor, indoor or temperature or humidity-controlled storage for both long- and short-term storage;
- Space requirements for outdoor, indoor and temperature- or humidity-controlled storage for both long-term and short-term storage;
- The procedures to be observed in unloading, placing, stacking and blocking of equipment;
- Rigging and lifting procedures;
- Maintenance procedures for both long- and short-term storage including maximum recommended storage period for items stored outdoors;
- Periodic rotation of components, where required;
- Application of protective coatings; and
- Cleaning of protective coatings and/or corrosion prior to installation.

1.3.17.4 Installation Instructions

Detailed instructions for the installation of the equipment shall be submitted together with reduced-size copies of applicable Drawings showing the erection sequence. The instructions and Drawings shall include information on handling and slinging the major pieces of equipment including weights, erection tolerances and special precautions to be observed during installation.

1.3.18 Operating and Maintenance Instructions

2.1.1.1.1 General

The Contractor shall provide sets of well structured, comprehensive and coordinated manuals to fully describe all aspects of design, operating and maintenance of all plant, equipment and systems provided under the Contract.

The Contractor shall arrange his manuals in three separate parts, namely Design, Operation and Maintenance. The layout of each part should, as far as possible, be consistent throughout each of the three parts, with systems, plant and plant described in the same order in each section. Each section shall be divided into as many volumes as necessary for convenient handling and reference.

Comprehensive indexing and cross-referencing shall be included to ensure easy access to information as required. A master index covering all three parts of the manuals shall be included in each volume, in addition to the detailed index for the particular section. PDF manuals shall include bookmarks and hyperlinks to facilitate navigation through the manual.

The manual format shall be on standard metric A4 sheets. Drawings and schedules, which are to be bound into the manual, shall be either A4 or A3 folded to A4.

Manuals from all sub-contractors shall be written in the same format.

The manuals shall include instructions only for the actual plant supplied and not for alternative or optional plant. For instance, a pump may have several different shaft sealing systems, but reference shall be made only to the system supplied.

All plant identification shall be by means of description and numbering systems specific to the Project as approved by the Employer.

Three hardcopy, and one pdf electronic copy of each manual shall be provided.

2.1.1.1.2 Scope of Manuals

The information to be provided in the manuals shall include, but not be limited to, the material listed in the following sections. They shall provide all necessary information for plant and procedures.

Design Manuals

The volume(s) comprising the design part of the manual should be laid out as follows:-

- Preliminary pages including index, preface, amendment record sheet and illustration of the complete plant.
- General description of the system including:-
  - System diagrams and block diagrams showing sub-systems and interconnection with other systems.
  - System description, including design basis, function, location and modes of operation.
  - Design data including calculations, performance curves, materials specification and running clearances and settings.
  - Instrument and valve lists itemising function, type, number, range and alarms.

Operation Manuals

The volume(s) comprising the operation part of the manual should be laid out as follows:-

Part A: Preliminary pages including index and amendment sheets.

Part B: Operating procedures and instructions for commissioning, start-up, normal operation, shut-down, standby, emergency action, on load and off load testing procedures.

- Normal range of system variables.
- Normal periodic servicing requirements.
- Operating limits and hazards.
- Procedures detailed under the heading of "Emergency Action" should include:-
  - *i. Action Upon Receipt of Alarm*
    - Alarm condition
    - Appropriate action
  - *ii. Emergency Procedures (for each major fault situation)*
    - Fault condition
    - Diagnostic procedure
    - Initial actions
    - Follow up action and operation

Part C: Testing and checking requirements.

Part D: Effect of loss of normal power.

Part E: System schematics and special diagrams should be included as necessary to enable operators to follow and understand the operating sequences; to perform safe isolations; and to become fully conversant with the plant without recourse to large-scale drawings.

Maintenance Manuals

The volume(s) comprising the maintenance part of the manual should be laid out as follows:-

Part A: Preliminary pages including index and amendment record sheets.

Part B: Maintenance data including the following:-

i. A schedule detailing the frequency of maintenance activities and the checks/servicing that are to be undertaken on a daily/weekly/monthly/annually basis.

ii. Permissible limits of wear of components and clearance, together with maximum and minimum 'as fitted' clearances, shall be shown for both preventive and overhaul procedures on specially prepared sectional diagrams. All points of measurement of radial and lateral clearances, and dimensions of components subject to wear under normal running conditions, should be identified by a lettered key. The key should provide in tabular form separate references for individual wearing dimensions and permissible clearances.

iii. Details and location of all springs.

iv. Details and location of all ball and roller bearings.

v. Details and location of all jointing materials, seals and 'O' rings.

vi. Details of weld preparations; types of electrodes; and preheating and stress relieving procedures for all joints which have to be broken and remade for normal overhaul and repairs. This information shall also be provided for other selected items, such as welded in valves.

Part C: Preventive Maintenance including list of tools required and list of component replacements normally required. All instructions should be submitted in a concise, tabular, check list form.

Sufficient sketches or drawings shall be included, where necessary, to enable the craftsman to comply with the instructions without recourse to full size engineering drawings.

Part D: Overhaul Maintenance including:-

i. A list of necessary engineering drawing numbers.

ii. A list of special tools required.

iii. A list of component spares normally required.

iv. A list of component weights of 500 kg and above.

All procedures shall be arranged in a logical sequence generally in the following order:-

i. Check list of operations prior to dismantling.

ii. Dismantling sequence, with details of any special methods to be adopted.

iii. Check list of inspections, which should include checks of permissible tolerances.

iv. Reconditioning, replacements and adjustments normally anticipated.

v. Re-assembly sequence, with details of any special methods to be adopted.

vi. Final checks pre-operational tests and special calibration tests.

Engineering drawings need not be included, but should be referred to as applicable. However, assembly drawings shall be included. Small illustrations and exploded views should, however, be inserted adjacent to the text concerned.

Part E: Instrument and Control System Maintenance. A broad outline of the plant shall be included in the Design Manual. The detailed description together with data sheets, shall be included in the Maintenance Section for:-

i. System and component fault finding.

ii. Component replacement and/or repair.

iii. Instrument calibration requirements and procedures.

iv. The requirements, as appropriate, specified for Mechanical and Electrical plant maintenance.

v. Test plant shall be listed in the manner specified for special tools.

Part F: Special Diagrams and Illustrations shall be provided for as follows:-

i. Logic diagrams are required to illustrate both the major sequences and the detailed step by step operation logic and to aid comprehension of complicated systems.

ii. Complementary functional diagrams shall be included as necessary to show in more detail the operation of a system or systems. The layout of the functional diagrams shall simplify the understanding of the operation of the systems, and need not bear any relationship to the physical size or location of the items.

iii. Electronic and electrical circuit diagrams shall conform with the layout of best engineering practice, component values and references being also given on the illustration. For testing and fault finding purposes, circuits shall include typical waveforms and voltages at points throughout the circuit and state the test plant used to obtain the waveforms and voltages.

iv. A component layout or wiring diagram shall also accompany a circuit diagram to assist the location of test points and components. This layout illustration should be a line drawing showing the sub-units and components in outline with relative sizes and locations shown in correct proportion.

Part G: Part Lists. The lists shall be presented in a logical engineering sequence (ie, Main Assembly, Sub-assembly and Components), the components being listed under their respective subassemblies. The lists shall include all items which are subject to replacement or repair.

Each Main Assembly, Sub-assembly and Component shall be designated with its complete ordering description and its detail drawing number or basic part number.

i. Where a "set" of items is listed, the items comprising the set and the detail drawing number or basic part number of each component shall be stated.
ii. Applicable material specification references shall be provided.
iii. The manufacturer's name, detail drawing number or basic part number shall be stated.

Exploded views shall be included where available, all parts being identified by item numbers.

Part H: Lubrication Schedule showing requirements and specifications for all plant covered by this Specification.

Part I: Cleaning and conservation procedures.

1.3.19 Field Commissioning Procedures of Check-Out, Start-Up, Initial Operation, Testing and Test Run

Manuals for the detailed procedures with applicable illustrations and diagrams for the sequential check-out, start-up, initial operation, testing and test run of the equipment after field installation shall be submitted. The instructions shall include:

- Components to be cleaned, checked and adjusted, with methods and precautions given;
- Methods of checking all clearances and
- Preliminary detailed operating and testing procedures for field check-out, start-up, initial operation, testing and test-run of the equipment.
- The procedures shall be submitted in a tabular form itemizing each operation and test, indicating the results expected in accordance with the design and leaving space for the actual observation during commissioning.

1.3.20 Reports

The Contractor shall furnish six (6) bound copies of all final reports related to the equipment including testing, initial operation, load rejection and load acceptance tests and the index and capacity tests. The reports shall be bound for permanent reference use.

1.3.21 Photographs

The Contractor shall furnish progress photographs of the factory and field erection work done. Photographs shall be taken at approximately quarterly intervals. Photographs shall be approximately 200 mm by 250 mm in size including a margin on one 250 mm side for binding. Approximately twenty-five (25) views each of the turbines and generators and five (5) views each of the inlet valves, governing systems and excitation systems will be required. Each photograph shall contain upon its face the date, the name of the manufacturer and the title of the view taken.

1.4 Quality Control & Testing Plans

Within 10 days after the Commencement Date, the Contractor shall provide a Quality Control Plan applicable to this Project.

The Contractor's Quality Control Plan shall comprise procedures for Quality Control and Quality Assurance. The plans shall include both design requirements and construction materials and workmanship requirements.

The Quality Control Plan shall define and document the Contractor's commitment to and policy for quality. The Contractor shall ensure that the policy and the associated procedures are understood, implemented and maintained at all levels in his organization, including all subcontractors. The Contractor's Quality Control Plan shall be based on well-established principles and proven performance.

The Quality Control Plan shall be supplemented as work proceeds with specific work and inspection procedures for all major activity. The work and inspection procedures shall include:

- Acceptance criteria, witness points and hold points specified in the construction requirements or in any standard or code adopted by the Contractor.
- Witness points for all the stages in the construction process where subsequent activities will disguise the quality and/or quantity of the previous activity thus making inspection and testing unfeasible, and/or where the subsequent activities will prevent correction of non-conformities.
- The Contractor shall issue relevant work procedures and inspection plans for the Engineer's review prior to the commencement of each main activity, unless stricter demands are specified in special cases.

The Contractor's Quality Control Plan shall be submitted to the Engineer for review. The Contractor shall monitor and approve his own work using the Quality Control Plan. The Engineer will monitor the Contractor's ability to follow approved plans and procedures throughout the entire project. The Contractor shall provide copies of review reports and test reports to the Engineer on a monthly basis.

The Engineer may audit the Contractor's records at any time to verify that sufficient reviews, checks, and tests are being performed. The Engineer reserves the right to:

- Include further stages as witness or hold points if these are considered to have been omitted by the Contractor;
- Change the designation of any stage from a witness point to a hold point should this be deemed necessary.
- Require all materials to be identifiable and traceable, unless otherwise stated.

1.4.1 Witnessing of Shop Assembly and Tests

The factory assemblies and tests specified for the various items of equipment will be witnessed by a representative of the Engineer, and the completed factory inspection and test forms showing the results will be signed by him. Copies of all factory inspection and test records shall be furnished to the Engineer. No equipment shall be shipped from the factory until it has been inspected and tested, or the inspection has been waived in writing by the Engineer. However, the waiver of any test or the witnessing of factory assemblies and tests by the Engineer shall not constitute a release of the Contractor's responsibility to meet fully the

requirements of this Contract. Prior to major factory assemblies and tests, the Contractor shall submit an outline of the procedures and tests it plans, to demonstrate fulfilment of the requirements specified in subsequent Parts of the Employer's Requirements under the heading "Shop Assembly and Tests" for the equipment.

1.4.2 Factory Tests

Factory tests shall be performed for main components and systems including but not limited to 11kV Switchgear. The Contractor shall inform the Engineer of all Factory Tests to be carried out and the Engineer shall have the right to inspect such factory tests.

Certified test results for tests previously performed on similar equipment may be submitted in lieu of performing dedicated factory tests, subject to review and approval of the Engineer.

1.4.3 Test and Commissioning Plan

Contractor shall provide a plan to perform Testing and Commissioning of the Works.

1.4.4 Training Program

The Contractor shall provide a plan to train the Employer's O&M personnel.

1.4.5 Materials

Current certificates of tests by manufacturers shall be available for inspection by the Engineer. Such certificates shall relate to the materials delivered to the Site and Contractor's work areas. Certified true copies of certificates may be submitted if the original certificates cannot be obtained from the manufacturer. A letter from the supplier certifying that the certificates are related to the delivered materials shall be submitted with the certificates. Parts and/or materials which are to be assembled on the sites and Contractor's work areas, shall be marked to identify the component parts.

Materials which are specified by means of trade or proprietary names may be substituted by the equivalent materials from a different manufacturer provided that the materials are of the same or better quality and comply with the specified requirements.

All materials and goods shall be stored strictly in accordance with the manufacturers instructions so as to insure no deterioration occurs prior to incorporation in the Works.

Materials and goods shall be stored to prevent harm to people's health or the environment.

1.4.6 Supplier Information

Contractor shall submit two (2) copies of technical data for major materials and equipment procured, including factory drawings, erection drawings, and supplier manuals.

1.4.7 Purchase Orders

Unpriced purchase orders, shall be submitted by the Contractor for all purchased materials and equipment and any subcontracted services. Every 30 days Contractor shall update and submit two (2) copies of the purchase order log.

1.4.8 Spare Parts Lists

Contractor shall provide a recommended priced spare parts list no later than 30 days after its placement of orders for materials and equipment.

1.4.9 Notice(s) of Equipment Inspections

Engineer will review purchase orders and advise Contractor of any tests or inspection hold points specified in the purchase orders that Engineer desires to witness. Contractor shall provide Engineer reasonable notice to witness these inspections and tests designated to be witnessed at suppliers' Works.

1.4.10 Shop Inspection and Test Reports

All factory inspection and test reports for Materials and Equipment shall be submitted to Engineer for review.

1.4.11 Quality Control Reports

The Contractor shall submit two (2) copies of quality control records such as, concrete test reports, structural steel bolting, weld inspections (visual, magnetic particle, X-ray), stress relieving, pump alignment, motor meggering, continuity wiring checks, etc.

1.4.12 Manufacturer Field Service Reports

All manufacturers' field representatives shall provide field inspection reports upon completion of each Site visit. Contractor shall submit these reports to Engineer.

1.4.13 As-Built Drawings

Contractor shall provide three (3) copies and one (1) reproducible of final plans for the civil works, P&ID's, electrical single-line drawings, and control logic diagrams, prior to issuance of the Taking-Over Certificate.

1.5 Drawings Furnished by the Employer

Any drawings furnished by the Employer, are not to be considered as defining the design of the plant to be furnished but are merely illustrative to show the general layout of the plant and for clarifying the Employer's Requirements. The Contractor shall provide standard proven designs, modified only to the extent required to comply with the Employer's Requirements.

1.6 Units of Measurement

The units of measurement to be used throughout this Contract shall be metric in accordance with ISO 1000:1992 "SI units, etc." On drawings or printed pamphlets where other units have been used, the equivalent metric measures shall also be shown.

1.7 Site Conditions

1.7.1 General Conditions

The equipment shall be suitable for operation at, and ratings shall be based on, the following conditions:

- Maximum outdoor ambient temperature for design purposes 40°C
- Minimum ambient air temperature 5°C
- Maximum average of 24 hours 32°C
- Relative Humidity 50 - 90%
- Average annual rainfall 4800 mm
- Thunder storm days per year (estimate) 50

1.7.2 Transport Limitations

The contractor shall be free to select the route for delivery of plant to site and shall be responsible for determining any limitations on route selections imposed by weight and/or size limits on roads, bridges, etc.

1.7.3 Water Conditions and Corrosion

1.7.3.1 Water Analyses

The Contractor shall perform his own analyses and evaluation of the water in determining that suitable materials are used for the equipment.

1.7.3.2 Design Provisions Against Corrosion

The Contractor shall design the equipment and provide materials that will give satisfactory service based upon his evaluation of the water characteristics.

1.7.3.3 Corrosion Resisting Bolts and Nuts

Corrosion resisting stainless steel or bronze shall be used for bolts and nuts when either or both are subject to contact with river water and/or frequent adjustment or frequent removal, such as adjusting bolts for packing glands on removable screens or strainers, on adjustable bearings, etc.

1.8 Spare Parts

1.8.1 Specified Spare Parts

The Contractor shall be responsible for providing all spare parts as specified by the Employer in the Specifications.

1.8.2 Optional Spare Parts and Maintenance Equipment

As part of the Basic Design, the Contractor shall provide a list of any recommended, Optional spare parts and maintenance equipment, including prices, and shall indicate the time required for delivery of each item to the site. Prices shall be valid for 1 (one) year after submission of the Basic Design which time the Engineer will decide which, if any, of recommended spare parts and maintenance equipment will be purchased from the Contractor.

1.9 Tools and Appliances

The Contractor shall provide one set of all special tools and appliances, including lifting gear, required for the proper maintenance of all the plant to be supplied and installed.
The term Special Tools shall include:-

- Sockets and spanners over 25 mm
- All tools requiring 20 mm (3/4 inch) square or hexagonal drives
- All fabric or steel slings and shackles over 2 tonnes capacity
- All torque, stretch or heat tightening equipment
- All lifting gear
- All special devices, jigs and instruments

Each tool and appliance is to be clearly marked with its size and/or purpose, and shall be handed over in new condition. The tools and appliances with the appropriate boxes or display boards shall be handed to the Engineer store in good condition not less than one month prior to commencement of the Tests at Completion.

1.10 Labels and Plates

The Contractor shall supply all name plates, caution plates and labels for the safe and efficient operation of the plant.

Each item of plant shall have permanently attached to it in a conspicuous position a nameplate or label of approved size and pattern. Before the manufacture of any nameplates or labels, the Contractor shall submit to

the Engineer a copy of the nameplate and label design standard for approval. All data, name plates and instruction plates on plant and cubicles shall be in the English language.

1.11 Standards

All design and construction work, including the materials used and methods applied, shall be in accordance with one or more internationally recognized standards of practice. By definition, such standards comprise organizations such as the IEC (International Electro-Technical Commission), ASTM (American Society for Testing and Materials), ISO (International Organization for Standardization), DIN (German Code), BS (British Standard), SS (Swedish Standard), EN (European Standard), or equivalent.

Should the Contractor request alternatives to the above standards, other relevant standards may be used subject to Employer's approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Employer for review and approval.

The latest editions on the Base Date of the standards and codes, including amendments, shall be used by the Contractor, unless expressly stated otherwise.

An English translation shall be submitted if the standards and codes proposed by the Contractor are in a language other than English.

All specific references to standards and codes throughout these Employer's Requirements are governed by this Part.

The Works shall be constructed in accordance with the laws of Fiji and associated Acts and Regulations. These include:-

- The National Building Code of Fiji -1990
- The Electricity Act (Chapter 180) – 1985
- Health and Safety at Work Act – 1996
- Environment Management Act

In order to achieve Regulatory compliance under the Fiji Electricity Act, the Works shall comply with the Electricity Regulations and AS/NZS 3000:2000 "Wiring Rules".

The standards under which the work is to be performed or tested are specified throughout these Employer's Requirements. Where such standards are in conflict with the provisions of these Employer's Requirements, the Employer's Requirements shall govern. In case of conflicting requirements that are not specified definitely in these Employer's Requirements between the standards of above authorities, such disagreements shall be resolved by the Engineer, and the Engineer's decision shall be final. It is understood that the latest revision or edition of such standards at the time of Tender shall apply.

In the absence of specific standards being nominated in the specifications, the following Standards shall apply:-

1.11.1 Australian/New Zealand Standards

AS/NZS	1170	Structural Design Actions
AS/NZS	1359.5	Rotating electrical machines—General requirements. Part 5: Three-phase cage induction motors—High efficiency and minimum energy performance standards requirements.
AS/NZS	1429.1	Electric cables - Polymeric insulated - For working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV
AS	1824	Insulation coordination – Definitions, principles and rules
AS	1940	The storage and handling of flammable and combustible liquids
AS	2067	Switchgear Assemblies and Ancillary Equipment for Alternating Voltages above 1kV
AS/NZS	2312	Guide to the protection of structural steel against corrosion by the use of protective coatings
AS/NZS	2373	Electric cables – Twisted pair for control and protection circuits
AS	2676.2	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings: Sealed cells
AS/NZS	3000	Wiring Rules
AS/NZS	3008	Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 (1.2) kV.
AS/NZS	3010	Electrical Installations – Generating Sets
AS	3011.2	Electrical installations – Secondary batteries installed in buildings, Part 2: Sealed cells
AS/NZS	3080	Telecommunications installations - Generic cabling for commercial premises
AS/NZS	3155	Approval and test specification - Electric cables - Neutral screened - For working voltages up to and including 0.6/1 kV
AS/NZS	3439	Low voltage switchgear and control gear assemblies
AS	4024	Safety of machinery, (all relevant parts)
AS	4044	Battery chargers for stationary batteries
AS/NZS	5000	Electric cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV.
AS/NZS	60265	High-voltage switches
AS	60529	Degrees of protection provided by enclosures (IP Code)
AS	60870	Telecontrol equipment and systems (All parts)
AS/NZS IEC	60947	Low voltage switchgear and controlgear

1.11.2 International Electrotechnical Commission (IEC)

IEC	60034	Rotating Electrical Machines – all relevant parts
IEC	60038	IEC Standard Voltages
IEC	60041	Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
IEC	60044	Instrument Transformers
IEC	60051	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC	60060	High Voltage Test Techniques
IEC	60071	Insulation Co-ordination
IEC	60072	Dimensions and output series for rotating electrical machines

IEC	60076	Power Transformers
IEC	60085	Thermal Evaluation And Classification of Electrical Insulation.
IEC	60086	Primary Batteries
IEC	60099	Surge Arrestors
IEC	60193	Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests
IEC	60228	Conductors of Insulated Cables
IEC	60255	Measuring relays and protection equipment
IEC	60269	Low-voltage fuses
IEC	60304	Standard colours for insulation for low frequency cables and wires
IEC	60308	Hydraulic turbines - Testing of control systems
IEC	60354	Loading Guide For Oil Immersed Transformers
IEC	60364	Low-voltage electrical installations
IEC	60446	Basic and safety principles for man-machine interface, marking and identification - Identification of conductors by colours or alphanumeric
IEC	60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV)
IEC	60534-4	Industrial Process Control Valve - Part 4: Inspection and routine testing
IEC	60545	Guide for commissioning, operation and maintenance of hydraulic turbines
IEC	60551	Determination Of Transformer And Reactor Sound Levels
IEC	60609-1	Hydraulic turbines, storage pumps and pump-turbines - Cavitation pitting evaluation - Part 1: Evaluation in reaction turbines, storage pumps and pump-turbines
IEC	60617	Graphical Symbols for Diagrams
IEC	60654	Industrial-process measurement and control equipment - Operating conditions
IEC	60664	Insulation coordination for equipment within low-voltage systems (All Parts)
IEC	60715	Dimensions of low voltage switchgear and control gear
IEC	60793	Optical fibres
IEC	60794	Optical fibre cables
IEC	60870	Telecontrol equipment and systems - All Relevant Systems
IEC	60896	Stationary Lead-Acid Batteries
IEC	60934	Circuit breakers for equipment
IEC	60994	Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines)
IEC	61000	Electromagnetic Compatibility
IEC	61116	Electromechanical equipment guide for small hydroelectric installations
IEC	61131-2	Programmable controllers
IEC	61131-3	Programming languages
IEC	61362	Guide to specification of hydraulic turbine governing systems
IEC	61439	Low-voltage switchgear and controlgear assemblies
IEC	61634	High-voltage switchgear and controlgear - Use and handling of sulphur hexafluoride (SF6) in high-voltage switchgear and controlgear
IEC	61660	Short-circuit currents in DC auxiliary installations in power plants and substations
IEC	61850	Power Utility Automation
IEC	61869	Instrument Transformers
IEC	61936	Power installations exceeding 1 kV a.c

IEC	62006	Hydraulic Machines - Acceptance tests of small hydroelectric installations
IEC	62040	Uninterruptible power systems (UPS)
IEC	62097	Hydraulic machines, radial and axial - Performance conversion method from model to prototype
IEC	62270	Guide for computer-based control for hydroelectric power plant automation
IEC	62271	High voltage switchgear and controlgear
IEC	62271-37-013	Alternating current generator circuit breakers

1.11.3 American National Standards Institute (ANSI)

ANSI/ISA	S5.1	Instrumentation Symbols and Identification
ANSI	B49.1	Shaft Couplings, Integrally Forged Flange Type for Hydroelectric Units
ANSI	S82.03	Safety Standard for Electronic Test, Measuring Controlling and Related Plant
ANSI	B16.104	ANSI/FCI 70-2 Control Valve Seat Leakage

1.11.4 Institute of Electrical and Electronic Engineers (IEEE)

IEEE	80	IEEE Guide for Safety in AC Substation Grounding
IEEE	485	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE	802.1 AB	Station and Media Access Control Connectivity Discovery
IEEE	802.1 D	Media Access Control Bridges
IEEE	802.1 Q	Virtual Bridged Local Area Networks
IEEE	802.3	Ethernet
IEEE	807	Recommended Practice for Unique Identification in Hydroelectric Facilities
IEEE	810	Standard for Hydraulic Turbine and Generator Integrally Forged Shaft Couplings and Shaft Runout Tolerances
IEEE	1095	Guide for Installation of Vertical Generators and Generator/Motors for Hydroelectric Applications
IEEE	1207	Guide for the Application of Turbine Governing Systems for Hydroelectric Generating Units
IEEE	1613	Standard Environment and Testing Requirements for Communication Networking Devices in Electric Power Substations

1.11.5 British Standards (BS)

BS	148	Unused Mineral Insulating Oils For Transformers And Switchgear
BS EN ISO	1461	Hot dip galvanized coatings on fabricated iron and steel articles
BS	6231	Specification for PVC-insulated cables for switchgear and controlgear wiring
BS	6651	Protection of structures against lightning.
BS	7354	Code of Practice for Design of high-voltage open-terminals stations, Section 7: Earthing.
BS	7430	Code of Practice for Earthing.

1.11.6 ASTM

ASTM	A27	Specification for Mild to Medium-Strength Carbon-Steel Castings for General Application
ASTM	A36	Specification for Structural Steel
ASTM	A487	Specification for Steel Castings Suitable for Pressure Service.
ASTM	A240	Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM	A275	Standard Method for Magnetic Particle Examination of Steel Forgings
ASTM	A282	Forged Stainless Steel Fittings, Socket-Welding and Threaded
ASTM	A285	Specification for Low and Intermediate Tensile Strength Carbon Steel Plates for Pressure Vessels (Plates 50 mm and Under in thickness)
ASTM	A312	Specification for Seamless and Welded Austenitic Stainless Steel Pipe
ASTM	A345	Specification for Flat Rolled Electrical Steel
ASTM	A388	Standard Practice for Ultrasonic Examination of Heavy Steel Forgings
ASTM	A403	Specification for Wrought Austenitic Stainless Steel Pipe Fittings
ASTM	A420	Specification for Stainless and Heat-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels
ASTM	A516	Specification for Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service
ASTM	A517	Specification for High Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels
ASTM	A582	Specification for Free-Machining Stainless and Heat- Resisting Steel Bars, Hot-Rolled or Cold-Finished
ASTM	A666	Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM	A668	Specification for Steel Forgings, Carbon and Alloy for General Industrial Use
ASTM	A743	Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base (Corrosion-Resistant) Alloy Castings for General Application
ASTM	B21	Specification for Naval Brass Rod, Bar, and Shapes
ASTM	B31.1	Power Piping
ASTM	B42	Specification for Seamless Copper Pipe, Standard Sizes
ASTM	B88	Specification for Seamless Copper Water Tube
ASTM	B127	Specification for Nickel-Copper Alloy Plate, Sheet, and Strip
ASTM	R0027	Standards Related to Nondestructive Testing Developed by ASTM Committees Other Than Committee E-7
ASTM	Vol 03.03	Nondestructive Testing

1.11.7 Other

ASME		American Society of Mechanical Engineers, "Boiler and Pressure Vessel Code," Division 2.
ASME	PTC Code 18	Hydraulic Turbines
CCH	70-3	Specification for inspection of steel castings of hydraulic machines.

All other equipment furnished under this section shall conform to the requirements of applicable Standards.

In addition to the Standards listed in the specification, and the Standards listed above all other aspects of the powerhouse and switchyard equipment shall be designed, manufactured and tested in accordance with the

pertinent provisions of the codes and standards of the following listed institutes, associations and other organizations:

Name	Abbreviation
American National Standards Institute	ANSI
American Society of Mechanical Engineers	ASME
American Society for Testing and Materials	ASTM
Australian Standards	AS
Australia/New Zealand Standards	AS/NZS
Institute of Electrical and Electronics Engineers	IEEE
International Electrotechnical Commission	IEC
Fijian Standards	FJS
New Zealand Standards	NZS

2 Mechanical Requirements

2.1 Workmanship

All materials shall be new, of a first-class nature. All materials shall comply with the latest relevant authorised standards for Testing Materials unless otherwise specified or permitted by the Engineer.

All workmanship shall be of highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown, and shall be built in accordance with, the approved drawings. All joints, datum surfaces and mating components shall be machined and all castings shall be spot faced for bolts and/or nuts. All machined finishes shall be shown on the approved drawings.

All screws, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization (ISO) covering these components and shall all conform to the standards for metric sizes. The Contractor shall use exclusively the standard and size system presented in his Tender and accepted and incorporated in this Contract.

2.2 Handrails

Adequate safety handrails and guards shall be provided around the plant, where necessary, to afford protection from all moving and electrical parts. Such items shall be designed to facilitate easy removal to permit free access to various parts of the unit.

2.3 Materials

Materials shall be new and of first-class quality, suitable for the purpose, free from defects and imperfections, and of the classifications and grades listed herein or their equivalents. Materials not listed herein may be used subject to the Engineer's review of their acceptability, application, and the maximum allowable design stresses established by the Contractor. Material specifications, including grade or class, shall be shown on the appropriate detail Drawings submitted to the Engineer.

Material	Specification
Carbon Steel Castings	ASTM-A27, Specification for Mild to Medium-Strength Carbon-Steel Castings for General Application, Grade 65-35, Grade 70-36, and Grade 70-40.

Material	Specification
Low-Alloy Steel Castings	ASTM-A148, Specification for High-Strength Steel Castings for Structural Purposes, Grade 80-50.
Corrosion-Resistant Steel Castings	ASTM-A743/A 743M, Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base (Corrosion-Resistant) Alloy Castings for General Application, Grade CA-15, Grade CF-8 and Grade CA-6NM.
Corrosion-Resistant Steel Plate	ASTM-A167, Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. ASTM-A176, Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip. ASTM-A240, Specification for Stainless and Heat-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels, Type 405 and Type 410.
Corrosion-Resistant Steel Bars	ASTM-A582, Specification for Free-Machining Stainless and Heat-Resisting Steel Bars, Hot-Rolled or Cold-Finished, Type 303 and Type 416.
Electrical Steel	ASTM-A345, Specification for Flat Rolled Electrical Steel.
Nickel-Copper Alloy Plate (Monel)	ASTM-B127, Specification for Nickel-Copper Alloy Plate, Sheet, and Strip.
Carbon and Alloy Steel Forgings	ASTM-A668, Specification for Steel Forgings, Carbon and Alloy for General Industrial Use, Class D.
Carbon Steel Forgings (for pipe flanges, fittings, etc.)	ASTM-A181, Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service, Grade I and Grade II.
Carbon and Alloy Steel Forgings	ASTM-A36, Specification for Structural Steel.
Carbon Steel Plates (for important stress-carrying parts)	ASTM-A285, Specification for Low and Intermediate Tensile Strength Carbon Steel Plates for Pressure Vessels (Plates 50 mm and Under in thickness), Grade B and Grade C.
Intermediate Strength Steel Plates (for important stress-carrying parts)	ASTM-A516, Specification for Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service, Grade 60 or better, except that all plates thicker than 25 mm (one inch) shall be normalized to produce grain refinement.
High Strength Steel Plates (for highly stressed parts)	ASTM-A517, Specification for High Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels.
Bronze Castings, Bronze (for bearings, wearing plates, etc.) Intermediate Strength Steel Plates (for important stress-carrying parts)	ASTM-B584, Specification for Copper Alloy Sand Castings for General Applications.
Bronze (for bolting) High Strength Steel Plates (for highly stressed parts)	ASTM-B21, Specification for Naval Brass Rod, Bar, and Shapes, Alloy No. 464.
Copper Tubing	ASTM-B88, Specification for Seamless Copper Water Tube,

Material	Specification
Bronze Castings, Bronze (for bearings, wearing plates, etc.)	Type K.ASTM-B584, Specification for Copper Alloy Sand Castings for General Applications.
Copper Pipe	ASTM-B42, Specification for Seamless Copper Pipe, Standard Sizes.
Steel Pipe	ASTM-A53, Specification for Welded and Seamless Steel Pipe.
Stainless Steel Pipe	ASTM A312, Type 316L Specification for Seamless and Welded Austenitic Stainless Steel Pipe..
Stainless Steel Pipe Fittings	ASTM A182, Type 316L Forged Stainless Steel Fittings, Socket-Welding and Threaded. ASTM A403, Type 316L Specification for Wrought Austenitic Stainless Steel Pipe Fittings.
Stainless Steel Tubing	ASTM A269 or ASTM A213, Grade TP316L Specification for Soft Annealed Stainless Steel Tubing.
Stainless Steel Tube Fittings	Compression type stainless steel flareless tube fittings, suitable for 1200 psi working pressure. To SAE J514.
Steel Pipe Flanges and Flanged Fittings	ANSI-B16.5, Steel Pipe Flanges and Flanged Fittings.

2.4 Test of Materials

2.4.1 General

All materials or parts used in the equipment shall be new and shall be tested, in conformity with applicable methods prescribed by the ASTM, or such other equivalent authorized organizations.

2.4.2 Impact and Bend Tests

Materials for all principal parts shall be tested for impact resistance using the Charpy "V" notch specimen and shall have an impact resistance of not less than 2.1 kg·m at 10°C. Testing shall conform to the requirements of ASTM A370 and E23. Both longitudinal and transverse impact tests shall be performed for each heat on plate steel. Bend tests shall be performed on specimens of all major steel castings and forgings, in accordance with the applicable ASTM designation. The nil ductility transition temperature shall be the temperature at which the impact resistance is 2.1 kg·m as specified above. Where plate material used for the principal parts is of a type which experience has shown will consistently meet the impact-nil ductility requirements specified herein, impact testing of plates may be eliminated, subject to the Contractors submitting data demonstrating satisfactory evidence.

2.4.3 Test Certificates

Certified material test reports shall be submitted as soon as possible after the tests are made. The test certificates shall identify the component for which the material is to be used and shall contain all information necessary to verify compliance with these Employer's Requirements.

2.5 Safety Factors and Design Stresses

2.5.1 General

The maximum allowable stresses in certain types of materials used in the equipment are specified herein. However, the Contractor shall be responsible for an adequate design based on factors proven safe in practice and shall use lower working stresses wherever it deems this necessary or desirable or where it deems deflection to be the controlling design criterion.

2.5.2 Maximum Allowable Stresses

Generous factors of safety shall be used throughout the design. Due consideration shall be given in the design of parts subject to alternating stresses, seismic stresses, fatigue, vibration, impact, or shock. Under the most severe conditions of loading expected in normal operation, stresses in the materials shall not exceed the values listed below. Maximum shear stresses in cast iron shall not exceed 21 MPa. Maximum shear stresses in other ferrous materials shall not exceed 60% of the allowable stresses in tension, except that the maximum torsional shear stresses in the shafting, including turbine and generator shafts and needles, shall not exceed 50% of the allowable stress in tension. For temporary overloads exceeding the maximum turbine output under the maximum net head, unit stresses shall not exceed one-half the yield strength. The design stresses for materials not listed herein shall be selected by the Contractor, but the maximum stresses in tension or compression shall not exceed one-third of the yield strength nor one-fifth of ultimate tensile strength. Under the maximum runaway speed conditions, or under hydrostatic test conditions, or generator maximum unbalanced transient forces caused by short-circuits, the stresses shall not exceed two-thirds of the yield strength.

Material	Maximum Allowable Stress	
	In Tension	In Compression
Gray Cast Iron	1/10 U.T.S.	70 MPA
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.
Carbon Steel Forgings	1/3 Y.S.	1/3 Y.S
Carbon-Steel Plate for Important Stress-Carrying Parts	1/4 U.T.S.	1/4 U.T.S.
High-Strength Plate Steel for Highly Stressed Parts	1/3 Y.S.	1/3 Y.S

U.T.S. = Ultimate Tensile Strength
Y.S. = Yield Strength

2.6 Tolerances

Machining tolerances for all mating fits shall be suitable for the intended service and shall be in accordance with ISO Standards.

2.7 Workmanship

All work shall be performed and completed in a thorough workmanlike manner and shall follow the best modern practices in the design and manufacture of the types of equipment specified herein. All Work shall be done by personnel skilled in the related professions and trades. All parts shall be made accurately to a standard gage, so as to facilitate replacement and repairs. All bolts, nuts, screws, rivets, threads, pipe, gauges, gears, and measurements or dimensions shown on the Drawings shall conform to customary standards. The Contractor shall provide and maintain in storage for at least 10 years, free of cost to the Employer, sufficient templates, gauges, patterns, and other records to enable the Contractor to make repair and replacement parts. All special gages and templates necessary for field erection shall be furnished and shall become the property of the Employer. Patterns will remain the property of the Contractor.

2.8 Welding

2.8.1 General

All welding shall be performed by the electric-arc method, by a process that excludes the atmosphere from the molten metal, and, where practicable, by automatic machines. After being deposited, all welds shall be cleaned of slag by shot blasting, unless otherwise approved, and shall be uniform, smooth, showing good fusion with the base metal, and free of voids, crack, and clinkers. Machined surfaces of parts affected by welding shall be machined to final dimensions after welding. Machined surfaces of parts requiring stress relief shall be machined to final dimensions after the parts have been stress relieved. Localized stress relieving will not be permitted for factory welded parts. All principal load carrying welds shall be full penetration type welds. Strength of welded joints shall be based upon the allowable stress of the parent materials specified in 2D.10, Safety Factors and Design Stresses.

2.8.2 Edge Preparation

Members to be joined by welding may be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. Design of welded joints and selection of weld filler metal shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects, such as laminations or defects caused by cutting operations, and free from rust, oil, grease and other foreign matter.

2.8.3 Welding Qualifications

The qualification of welding procedures, welders, and welding operators for all welding of pressure-containing components, including weld repairs and other high stressed components, shall conform to standards at least equal to Section IX of the ASME "Boiler and Pressure Vessel Code". For welding of structural parts, the qualifications shall conform to standards at least equal to the AWS "Standard Qualification Procedure." The Contractor shall furnish the facilities and all equipment, materials, and other articles required to perform qualification tests of its welders and welding operators. Certificates of welders' qualifications shall be furnished when requested. The procedure for qualification testing of the field welders shall be prepared by the Contractor, and the qualification tests shall be witnessed and accepted by the Contractor.

2.8.4 Field-Weld-Filler Metal

The calculated quantity of weld-filler electrodes or wire required for field-welded joints plus 20% additional shall be furnished. The Contractor shall select the proper filler material for all field-welded connections and shall specify it on the applicable Drawings submitted for the Engineer's approval, together with the detailed design of the field-weld joint.

2.8.5 Documentation

The Contractor shall maintain a strict quality control program for the welding work performed in the factory. Weld procedure specifications (WPS) shall be submitted for review prior to starting the fabrication work. All welds shall be identified on the Contractor's Drawings by numbers. All welding work shall be performed by qualified welders and welding operators and shall be properly documented.

2.9 Fabrication

All weld-fabricated pressure-containing parts shall be designed, fabricated, inspected, and tested, unless otherwise specified, in accordance with standards at least equal to Section VIII, Division I, of the ASME "Boiler and Pressure Vessel Code" and shall be stress relieved as a unit prior to final machining. Steel plates shall be annealed at a temperature between 600°C and 650°C before rolling or pressing to final shape, except that high-strength type quenched and tempered alloy steel plates shall not be annealed.

2.10 Non-destructive Testing

2.10.1 General

Unless otherwise indicated, all non-destructive tests shall be in accordance with the applicable section of ASTM Standards, Part 11, "Metallography Non-destructive Tests" or approved equivalent. The Contractor's Drawings submitted for review shall define the areas, extent, and type of non-destructive examination employed.

2.10.2 Examination of Welds

All welds on weld-fabricated parts, except minor parts or low stressed parts, shall be given complete non-destructive examination. Weld examination shall be by ultrasonic, dye penetrant and magnetic particle methods, supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretations of other methods are unclear, or where the integrity of the weld is doubtful. All butt welded joints exposed to head water pressure, or to significant stress levels shall be given a 100% radiographic or ultrasonic inspection accompanied by a 100% magnetic particle or liquid penetrant inspection. The Engineer shall have the right to request random spot-check examination of welds, including radiographic examination, as part of his inspection of the equipment. The non-destructive examination scope, procedures and acceptance standards of welds shall be clearly indicted on the Drawings. The detailed program for non-destructive examination of welds shall be submitted for review. Radiographic examination of welds shall be in accordance with the technique and acceptance standards of Paragraph UW-51 of Section VIII, Division 1, of ASME "Boiler and Pressure Vessel Code." Ultrasonic examination of welds shall

be in accordance with the methods and acceptance standards of the ASME Code, Section VIII, Division 1, Appendix 12. Magnetic particle examination of welds shall be in accordance with the methods and acceptance standards of the ASME Code, Section VIII, Division 1, Appendix 6. Liquid penetrant examination of welds shall be in accordance with the methods and acceptance standards of the ASME Code, Section VIII, Division 1, Appendix 8.

2.10.3 Examination of Castings

Major castings incorporated in the equipment or their components that are castings, shall be given complete non-destructive examination by ultrasonic, dye penetrant, and magnetic particle methods supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretation of other methods is unclear or where the integrity of the casting is doubtful. Non-destructive examination of other castings shall be in accordance with accepted good practice to assure sound castings and shall be indicated on the Drawings. The non-destructive examination of steel castings shall be in accordance with the following methods and acceptance standards:

Examination Method	Standard for Method	Standard for Acceptance
Radiographic	ASME Sec. VIII, Div. 1, Appendix 7	ASME Sec. VIII, Div. 1, Appendix 7
Ultrasonic	ASME Sec. V, Art. 5	ASME Sec. V, Art. 23, SA609
Magnetic Particle	ASME Sec. VIII, Div. 1, Appendix 7	ASME Sec. VIII, Div. 1, Appendix 7
Liquid Penetrant	ASME Sec. VIII, Div. 1, Appendix 7	ASME Sec. VIII, Div. 1, Appendix 7

2.10.4 Examination of Forgings

Forgings for the shafts, needles (if made of forgings), and shaft coupling bolts shall be given complete ultrasonic examination with liberal overlap and other approved non-destructive tests, to determine that they are sound. Non-destructive examination of other forgings shall be in accordance with accepted good practice to assure their soundness and shall be indicated on the Drawings. The structure of forgings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a forging will be cause for its rejection. Examination of steel forgings shall be in accordance with the methods and acceptance standards of ASTM A388, "Standard Practice for Ultrasonic Examination of Heavy Steel Forgings," and of ASTM A275, "Standard Method for Magnetic Particle Examination of Steel Forgings."

2.11 Steel Castings

2.11.1 General

Castings shall be free from injurious defects and shall be satisfactorily cleaned for their intended use. Surfaces of castings which do not undergo machining and which are exposed to view in the installation shall be dressed for good appearance and for painting. The locations of existing defects shall be determined, and all defects,

which impair the strength or utility of the casting, shall be removed to sound metal. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a casting will be cause for its rejection. Bend tests shall be performed on all major castings as specified under 2D.9, Test of Materials.

2.11.2 Inspection

Castings shall be inspected visually at the foundry after they are cleaned, while test pieces are removed, and while defects are being removed. Castings shall also be inspected after repairs and after heat treatment. Radiographic or other non-destructive tests will be required as specified under 2D.15, Non-destructive Testing, and as otherwise approved by the Engineer when granting permission to repair major defects. The Engineer reserves the right to require non-destructive tests at the Contractor's expense to determine a) the full extent of defects, b) that the area is properly prepared for welding, and c) that the repairs are satisfactory.

2.11.3 Repair Welding

Before proceeding with repairs the Contractor shall submit a descriptive report on the casting defects, including Drawings showing the location and size of major and minor defects, supplemented with photos, sketches and metallurgical test reports, results of non-destructive examinations, dimensional stability, metal wall thickness, shrinkage, perforations, etc. The report shall define the type of defect, probable causes and the changes recommended in the design of the component or in the casting technique to prevent similar defects in consecutive castings. Similarly, the detailed repair procedure shall be submitted, including the non-destructive tests to be applied and the finished repair. Minor defects or imperfections that will not impair the strength or serviceability of the castings may be repaired by welding in accordance with accepted foundry practice without approval but in any case shall be reported to the Engineer. Defects shall be considered minor when the cavity properly prepared for welding is not greater than 25% of the actual wall thickness but in no case greater than 25 mm and when the area to be welded is not greater than 160 cm^2. An accumulation or concentration of minor defects shall be considered as a major defect. The accumulation of major defects and/or concentration of minor defects which in the opinion of the Engineer casts doubt as to the quality of the casting may be cause for its rejection. If removal of the defects reduces the stress-resisting cross section of the casting by more than 30% or if the calculated stress in the remaining metal exceeds the allowable stress by more than 30%, the casting shall be rejected. All castings having major defects repaired or accumulation of minor defects after heat treatment, or any defects which will impair the strength of the stress-resisting cross section or the dimensional stability of the finished part repaired after heat treatment, shall be reheat treated.

2.11.4 Dimensions

Dimensions of castings shall not be reduced by factory or foundry practices by an amount sufficient either to impair by more than 10% the strength of castings (calculated from Drawing dimensions) or to cause the stresses to exceed those allowed under these Employer's Requirements. Dimensions shall not be oversized to the extent that the castings interfere with processing operations or proper fit with other parts. Warped or otherwise distorted castings shall not be used in the Work without presenting complete details for review.

2.12 Surface Finish of Equipment Parts and Welds

2.12.1 Weld Finish

Welds shall in general be treated so that they will display good appearance and a surface suitable for painting. Structural welds shall be ground and blended, to avoid stress raisers. All welds which require radiographic or other non-destructive examination shall be dressed by chipping and grinding as required for good interpretation of radiographic film or interpretation by other weld examination methods. Welds exposed in water passages shall be ground to provide smooth-contoured hydraulic surfaces. The welded joints of the air receivers and oil pressure tanks shall not be ground to the extent that the tank is weakened structurally. Details of weld dressing and finishing and non-destructive testing (NDT) shall be shown on the Drawings submitted for approval.

2.12.2 Hydraulic Packing

Packing for seals shall be a high-grade commercial product and where feasible, with polytetrafluorethylene (PTFE) content suitable for the application and for long seal life. Packing grooves, which are exposed to river water, shall be protected from corrosion, by the use of corrosion-resistant materials.

2.12.3 Auxiliary Equipment and Data

Items of equipment such as pumps, motors, valves, and similar small pieces of equipment and accessories shall be, to the greatest extent practicable, of a type that is readily available or can be readily imported. The names of manufacturers of mechanical and electrical auxiliary equipment to be incorporated in the work, together with performance characteristics and other significant information, shall be submitted to the Engineer for review. Equipment incorporated in the work without prior review and approval shall be subject to rejection.

2.12.4 Nameplates

Each major and auxiliary item of equipment shall have a nameplate permanently affixed thereto showing in a legible and durable manner the serial number, name and address of the manufacturer, ratings, characteristics, weight, manufacturing date and other significant information, as applicable. Nameplates of distributing agents only shall not be acceptable.

Additional nameplates shall be provided to indicate main operating instructions, caution or warning for personnel and operational safety. In addition, each panel-mounted instrument, position indicator, pushbutton, switch, light, or other similar device shall be identified by a permanently affixed nameplate describing the control functions. Electrical wiring and instruments including relays shall also be labelled to correspond to the numbers assigned on the electrical control schematics.

The above general nameplate requirements shall be used in preparing nameplate lists and Drawings to be submitted to the Engineer for review. Drawings for nameplates, as they will appear on the finished equipment, shall be submitted for review.

All nameplates shall be in English and shall be suitably engraved and shall be weather-resistant. All nameplates shall be permanently attached to the respective parts, components, or equipment items in clearly visible locations. Nameplates for control equipment shall be screw mounted laminated plastic, white with black cores, with engraved capital letters 6 mm minimum height.

2.13 Piping

2.13.1 General

Piping, pipe materials, pipe supports, and hangers shall be in accordance with standards at least equal to ANSI B31.1.0, "Power Piping." The arrangement of piping and locations of valves and joints shall be such that there will be minimum disturbance of the piping and interference with other equipment and systems when the turbine, generator, or other equipment is dismantled or parts are removed for inspection or repairs. Bolted flange connections or unions shall be provided at points where a piping system must be disconnected for dismantling.

2.13.2 Water Piping

Water piping shall be of welded grade 316L stainless steel pipe. Piping connection shall be of welded joints for embedded water piping and welded joints and flanged fittings for exposed water piping. Valves 75 mm and smaller shall be of stainless steel; valves 100 mm and larger shall be cast steel flanged valves with stainless steel trim, epoxy-coated inside.

Sanitary water pipe downstream of the storage tank may be copper or polybutylene.

Insulation

Insulate all hot surfaces, pipe, valves, fittings to ensure surface temperature is low enough to be safe to touch and to prevent excessive heat loss. Insulate all cold surfaces to prevent condensation being formed on the surface and to prevent excessive heat gain. Insulation on cold surfaces shall be vapour sealed type to prevent migration of vapour from the warm side into the insulation. No insulation is to be applied to pipework until they have been proven to be water, air and gas tight as applicable.

All thermal insulation and cladding systems shall be in accordance with the requirements of BS 5970 - Code of Practice for the Thermal Insulation of Pipework and Equipment.

Thermal insulation shall be in-situ foamed polyurethane type with aluminium cladding. Foam glass ferrules shall be used at pipe support locations. Water lines shall be insulated and clad such that no condensation forms on the surfaces of the pipe, cladding or pipe supports under normally expected operating conditions and temperatures.

All pipework and equipment insulation is to be neatly trimmed around valve bonnets, drain cocks, vents, etc. to enable normal operation and maintenance without the need to remove the insulating material.

2.13.3 Oil Piping

Pressure piping for jacks and servomotors shall be grade 316L stainless steel, of appropriate strength, with steel fittings and steel bodied valves. Valves shall have bronze seats and stems. Lubricating oil piping shall be seamless drawn copper or red brass with brass or bronze fittings and valves.

2.13.4 Piping Integral with Turbine Water Passages

Piping for the distributor drains turbine pit drain, and any other lines connected to the penstock, turbine, or distributor shall be welded steel pipe, epoxy-coated inside, with flanged fittings. Valves 75 mm and smaller shall be of grade 316L stainless steel; valves 100 mm and larger shall be cast steel, flanged, wedge disc gate valves with stainless steel trim, epoxy-coated inside.

2.13.5 Piezometer and Pressure Tap Piping

Piezometer and pressure tap piping on the turbine shall be 20 mm grade 316L stainless steel tubing and fittings, as specified in 2D.8, Materials. All piezometer taps shall be individually piped to valve panels provided at suitable locations. Each piezometer line shall be valved and labelled at the valve panel. Provisions for blowing out the lines with compressed air, for venting air from the lines and for connection to pressure measuring devices shall be included.

2.13.6 Compressed Air Piping

Compressed air piping for pressures up to 9 bar shall be ASTM-A53 Schedule 40 black steel pipe, welded grade, with screwed fittings for sizes up to 60 mm and with butt weld fittings for larger sizes. ASTM-A53 Schedule 80 black steel, seamless pipe shall be used for higher pressures with screwed or socket-weld forged steel fittings.

2.13.7 Instrument Piping

Piping exposed to river water shall be grade 316L stainless steel tubing with stainless steel compression type fittings and shut-off valves. All other piping shall be brass or copper with brass or bronze screwed fittings or of copper tubing. Shut-off valves shall be provided at pressure gauges and at points where the gauge piping connects to the main equipment, together with suitable blow-off valves and drain connections. Flexible tubing for the dial thermometers shall be armoured.

2.13.8 Governor and Inlet Valve Oil Pressure Piping

The governor and inlet valve shall be provided with interconnecting piping and valves between the various parts of the oil pressure systems and their respective operating servomotors. The piping shall be sized for a maximum oil velocity of 5.0 m/s for servomotor travel at the maximum rate. The main pressure oil piping shall be grade 316L stainless steel pipe with welded joints and bolted steel flanges, or threaded connections for any connections required to permit assembly and disassembly of the piping system. Threaded pipe connections shall use stainless steel connections complying with SAE J514. All piping shall be thoroughly cleaned by

pickling in the factory (removing all mill scale, loose or tight), oiled inside, painted on the outside and protected for shipment by wooden protectors on all flanges and protective closures on pipe ends. All valves, except valves built-in and forming an integral part of the governor pumping unit, shall be of the rising-stem, steel body type. Gate valves in the pressure lines shall be cast-steel, solid-wedge type, with close guide clearances to minimize vibration of the gates when operating at partial opening. Where feasible, long-radius pipe bends shall be used in place of pipe fittings. Piping shall be factory fabricated to the maximum extent possible, consistent with erecting, handling, and shipping requirements.

2.13.9 Carbon Dioxide Piping

Carbon dioxide system piping up to and including 20 mm shall be standard weight galvanized steel; carbon dioxide piping larger than 20 mm shall be extra heavy galvanized steel.

2.13.10 Pipe Supports and Piping Materials

Adequate pipe supports shall be provided for all piping included in the supply. Supports, pipe hangers, wall brackets, pipe clamps, fastening devices and all necessary studs, bolts, nuts, washers, oil-resistant gaskets, packing, etc., required for the piping systems shall be furnished. These items shall be supplied as finished products requiring no field fabrication such as welding, cutting and drilling.

2.13.11 Piping Connections

On connections for all equipment, pipes may be threaded or flanged with the flanges faced and drilled in accordance with standards selected by the Contractor. All flanged external connections shall be provided with bolts, nuts and gaskets for connection to piping furnished by others. All governor and inlet valve oil piping, generator oil lubricating piping, high pressure oil lift piping, generator brakes and jack piping, generator oil mist piping, generator CO_2 piping, generator brake dust collection piping, etc. shall be furnished as a part of a complete system.

2.14 Pumps

2.14.1.1 General

Pumps shall be installed strictly according to the pump manufacturer's requirements. Every effort shall be made to ensure that the minimum number of pump vendors are used as suppliers, and that pumps with identical duties are interchangeable in every respect.

The pump and motor combination shall be selected so that non-overloading operation is ensured under all flow conditions.

2.14.1.2 General Requirements for Pumps

Pumps shall be of a design and capacity capable of maintaining the fluid flow rate at the actual system resistance. The material and construction of the pump shall be suitable for the type, temperature and pressure of the fluid to be handled.

All moving parts of the pump shall be statically and dynamically balanced.

All pumps shall either be fitted with mechanical seals or be of canned construction so there is no liquid path past a moving surface. Mechanical seals shall be used wherever possible. The preferred sealing face combination is carbon on silicon carbide. Seals shall be water flushed wherever practicable.

2.14.1.3 Centrifugal Type Pumps for General Use

Pump installations shall consist of pump casing, impeller, suction and discharge connections, driven shaft, couplings and motor as stated. Pumps shall be complete with all necessary water seals. Pump installations shall comprise suction and discharge pipe reducers and expansion pieces directly connected to the pump connections, vibration isolation equipment, and motor terminal box suitable for connection to a flexible conduit system.

Generally, pump base plates shall be constructed from cast iron, however unit constructed close coupled pumps may be mounted on mild steel rails or a fabricated mild steel flat bed plate if full corrosion resistant surface treatment is provided.

Pump flanges shall be tapped and plugged to receive gauge connections.

Volute casings shall be drilled, tapped and plugged at the bottom to enable complete drainage to be carried out.

Spherical roller bearings, or in light load applications deep groove ball bearings, are required on all pumps using rolling element bearings and shall be arranged to operate either within an oil reservoir or with grease lubrication. Parallel roller bearings are not permitted. Bearing lubricators shall be fitted with drain plugs and oil content indication.

Impellers and couplings shall be keyed to the drive shaft, the impeller being retained by a hexagonal nut. Shafts shall be fitted with water deflectors.

Unless specifically indicated elsewhere in this document, motor enclosures shall be totally enclosed fan cooled.

Belt driven pumps shall not be permitted, except in the case of gear pumps.

Unit-constructed close coupled pumps shall be of the back pull-out type, enabling the motor, drive and impeller to be withdrawn from service without disturbing the volute casing connections, piping, etc.

Where pumps are to be coupled to their prime mover on site, the motor and pump shall be carefully levelled on shims and packing to achieve a close order of alignment. Dial gauges shall be used to achieve this end and the maximum permitted eccentricity shall be 0.05 mm.

Care shall be taken that the connecting pipe is so arranged as to ensure that no stresses are transmitted through the connections to the pump casing.

2.14.1.4 Performance

The Contractor shall provide pump characteristics, power and efficiency curves certified by an internationally recognised authority to the Engineer for approval.

All pumps shall operate with no cavitation. In the case of pumps operating at elevated temperatures, the Contractor shall demonstrate to the Engineers satisfaction, the no cavitation will occur under all normal operation conditions. Detailed NPSH calculations shall be submitted for approval by the Engineer.

2.15 Foundation Materials

2.15.1 General

All permanent foundation materials including all anchor bolts, jacks, tie rods, turnbuckles, anchor loops, levelling screws, supporting columns made of pipe or structural steel, soleplates, embedded anchor plates, bracing, and all other foundation materials required for anchoring and/or supporting the parts during concreting, shall be furnished with the equipment.

2.15.2 Design

Tie-down rods and bracing for the distributor shall be designed to firmly hold it in place while it being embedded. Tie rods for the wheel pit liner and pit liner shall be similarly designed. The necessary bars required to transfer the uplift or downpull on the turbine components into the surrounding concrete shall be designed and furnished. All jacks shall have steel bases and steel caps so that they can be welded to the parts which they support and to the jack supports.

2.15.3 Anchor Bolts

All anchor bolts and anchoring materials, including pipe sleeves, nuts, and plate washers required for anchoring the equipment and accessories, shall be furnished. Calculations showing the stresses in the anchor bolts for the needle servomotors and their operating cylinders shall be submitted for review.

2.16 Handling Devices

The rotor lifting device for attaching to the powerhouse crane shall be provided. Lifting brackets for attaching to the top of the turbine shaft, and the generator shaft shall also be provided. In addition, upending shoes required to upend the shafts from the horizontal to the vertical position shall be furnished. The Contractor shall coordinate the rotor and shaft handling details with the Engineer.

Lifting lugs, brackets, eyes etc., as required for attaching lifting devices shall be provided on all of the major components of the equipment. All slings and lifting devices required for attachment to the components and assemblies and to the powerhouse crane-hook for handling during erection and disassembly shall be furnished.

2.17 Protection, Cleaning and Painting

2.17.1 General

All ferrous parts shall be protected, cleaned and painted in accordance with AS/NZS2312 "Guide to the protection of structural steel against corrosion by the use of protective coatings". Where the requirements of this Standard differ from the requirements of the specification, the more onerous requirement shall apply.

All parts which will ultimately be embedded in concrete shall be cleaned and protected by a cement wash or other approved method before forwarding from the Contractor's factory. Before being installed, they shall be thoroughly de-scaled and cleaned of all rust and adherent matter. Such cleaning must not affect the strength or final operation or function of the plant.

All machined parts or bearing surfaces shall be cleaned and protected from corrosion by the application of an approved rust preventive lacquer or a peelable plastic film before forwarding from the Contractor's factory. Where the latter is impractical, such parts shall be heavily covered with high melting point grease. After erection, such parts shall be cleaned with solvent and wiped or polished bright.

All parts, other than machined parts that will be exposed after erection, shall be thoroughly cleaned and given two coats of best quality approved primer and one coat of best quality approved finish paint before being forwarded from the Contractor's factory. One further coat of paint of an approved quality and colour shall be applied after erection and touching up on the Site (except such apparatus as panels and instruments which shall be finish painted in the factory). Paint colours shall be submitted to the Engineer for approval by presentation of RAL 'Classic' or equivalent colour samples or colour chips

Primer shall be applied to surfaces prepared in accordance with the paint Contractor's instructions. The surface shall be wiped clean immediately prior to applying the paint. The primer and finish coats of paint shall be applied using the methods and plant recommended by the manufacturer.

The internal surface of all pipelines shall be cleaned out by approved methods before installation and again prior to commissioning, to ensure freedom from dirt, rust, scale, welding slag, etc. All exposed pipes shall be coloured for identification after erection is completed. The colour for each classified pipeline shall be approved by the Engineer.

The final colour of all plant shall be approved by the Engineer. The Contractor shall comply with this colour scheme for the plant.

All plant shall be painted as specified herein. The painting of plant shall include the preparation of the metal surfaces, paint application, protection and drying of the paint coatings, as well as the supplying of all tools, labour and materials necessary for the entire painting work.

Paint shall be the product of reputable manufacturers and its selection shall be approved by the Engineer. Sufficient paint shall be provided for site painting.

2.17.2 Employers Colour Scheme

The Employers Colour Scheme for the Wailoa powerhouse and appurtenant facilities is as follows:-

Item	*Colour*	*RAL*
Powerhouse		
Building Cladding	Mist Green/Pale Eucalypt	
Steel Frame	Caulfield Green/Cottage Green	
Handrails	Signal Yellow	RAL1003
Stairway Bearers	Signal Yellow	RAL1003
Ladders	Signal Yellow	RAL1003
Doors and frames	Karaka Green	
Roller Door	Mist Green/Pale Eucalypt	
Powerhouse & Laydown floor	Signal Grey	RAL7004
Powerhouse & Laydown floor "walkway markings"	Signal Yellow	RAL1003
Control Building Interior Walls	Papyrus White	RAL9018
Control Building Interior Ceilings	Cream	RAL9001
Control Panels	Grey	RAL 7032
11kV Switchgear	Grey	RAL 7032
Distribution Boards	Grey	RAL 7032
Turbine	Light Blue	RAL5012
Generator	Mellon Yellow	RAL1028
HPU	Patina Green	RAL6000
Main Inlet valve	Patina Green	RAL6000
Dewatering Valve	Patina Green	RAL6000
Lube Oil	Patina Green	RAL6000
Penstock Stub Section	Patina Green	RAL6000
Fire Pipework	Signal Red	RAL3001
Transformers	Green Grey	RAL7009
Crane and rails	Signal Yellow	RAL1003
Flood Pump Piping	Patina Green	RAL6000
Switchyard		
Building Cladding	Mist Green/Pale Eucalypt	
Doors and frames	Karaka Green	
Roller Door	Mist Green/Pale Eucalypt	
Floor	Signal Grey	RAL7004
Interior Walls	Papyrus White	RAL9018

Interior Ceilings	Cream	RAL9001
Control Panels	Grey	RAL 7032
Transformers	Green Grey	RAL7009

2.17.3 Surface Preparation

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted using solvents. All weld spatters, slags, burrs, loose rusted mill scale and other foreign substances shall be removed by shot or sandblasting to *"white"* metal. The interior surface of the steel pipe shall be mechanically cleaned or sandblasted to a commercial standard.

Special attention shall be given to cleaning of corners and converging angles. If rust forms or the surfaces become contaminated in the interval between cleaning and painting, re-cleaning to the same degree appropriate is required. Effective means shall be provided for removing all free oil and moisture from the air supply lines of blasting plant. All surface preparations shall be subject to the approval of the Engineer before any paint is applied.

2.17.4 Application Procedure

All paint, when applied, shall provide a satisfactory film and a smooth, even surface. Paint shall be thoroughly stirred, stained, and kept at the uniform consistency during application. Paint shall not be applied when the temperature of the metal or of the surrounding air is below 10°C. Surfaces that will be coated shall be performed by brushing or spraying. Each coat shall be allowed to dry or harden thoroughly before the succeeding coat is applied.

2.17.5 Surfaces Not to be Painted

Bronze, brass, surfaces of gear teeth, finished ferrous surfaces, surfaces in rolling or sliding contact after field assembly and wire ropes shall not be painted.

All corrosion resisting steel surfaces for bearings and machinery parts shall not be painted.

On completion of cleaning, such surfaces shall be coated with an adhesive plastic film to protect the surfaces from minor mechanical damage and corrosion during shipment and storage at the site. The film shall be stripped off immediately prior to field erection of the plant.

2.17.6 Galvanising

Unless specifically mentioned to the contrary, iron and steel shall be effectively galvanised after all fabrication is completed.

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible. Galvanising shall be applied by the hot dip process for all parts other than steel wires. All steel wires shall be galvanised by an approved method before stranding.

The minimum quantities of zinc coating shall be 350 g/m² for bolts and nuts and 550 g/m² for all other parts except steel wires. The uniformity of zinc coating, tested by dipping the sample into the solution of sulphate of copper, shall be such that no surface of iron or steel shall expose until four times of dipping for bolts and nuts and six times for all other parts.

The preparation for galvanising and the galvanising itself shall not distort or adversely affect the mechanical properties of the materials. After galvanising, holes shall be free from nodules of splatter.

Galvanised parts are subject to the formation of white rust during shipment or storage on the Site, and special treatment shall be made during the galvanising process to prevent the formation of white rust.

2.17.7 Paint Schedule

The painting shall be performed as follows:-

Epoxy resin paint, total thickness of 0.15 - 0.25 mm shall be applied to the following items:-

- Interior & external surfaces of steel conduits and valves
- Interior & exterior surfaces of turbine housings

All unfinished surfaces of ferrous metal except those specified in the above shall be given phthalic acid resin paint of alkyl resin enamel or other approved paints. Total thickness of these paints including primer coat shall be 0.12 - 0.15 mm. Commercial plant shall be painted in accordance with the manufacturer's standard practice.

All finished surfaces of ferrous metals including screw threads that will be exposed during transportation or while awaiting installation shall be cleaned and given a heavy uniform coating of gasoline soluble, rust preventive compound.

2.18 Lubricants and Hydraulic Fluid

Oil for the hydraulic power units, for the governing systems, inlet valves, and the thrust and guide bearings shall be of the same type. Grease, lubricating oil and hydraulic fluid required for initial filling of all of the equipment plus 10% shall be furnished. Upon completion of the design, a tabulation confirming the quantities of lubricating oil, grease, and hydraulic fluid required for initial application for each item of equipment shall be furnished. Final selection of the grease, lubricating oil, and hydraulic fluid shall be coordinated with the Engineer to rationalize the oil inventory and to ensure that the selected brands are available locally.

2.19 Ventilation and Air Conditioning Systems

2.19.1 Ductwork

2.19.1.1 General

Fabricate all ductwork in accordance with the appropriate Duct Manual produced by the Sheet Metal and Air Conditioning Contractor's National Association (SMACNA). Install all ductwork in accordance with the recommendation of SMACNA and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

Unless otherwise specified, ductwork shall be designed for a minimum operating static pressure of 500 Pa.

2.19.1.2 Duct Materials

Rigid Rectangular Duct - unless otherwise specified, duct material shall be galvanised sheet steel for indoor ductwork. Duct material shall be aluminium, or where specifically called for, stainless steel, for ductwork outside the building exposed to weather, or sheltered but not enclosed.

Flexible Connections - flexible connections shall be barium or lead loaded fabric, suitably rated for the specific application to limit noise breakout.

Flexible connection shall be secured as follows:-

- On circular ducts : "Jubilee" type fasteners.
- On rectangular ducts : Secure with approved "Soft" sealing compound and metal strip, fastened at not less than 80mm centres by self taping screws.

Flexible Ductwork - Ensure that the radii of bends in these ducts does not exceed the manufacturer's recommendations.

Flexible ductwork shall only be used for a maximum total length of 3 m of in any branch.

2.19.1.3 Duct Construction & Installation

Ducts shall be constructed to the requirement of SMACNA. Pressure rating of ductwork shall exceed maximum operating pressure of the duct work system.

All rectangular ductwork shall be suitably stiffened in accordance with SMACNA recommendation. Flat panels of ducts shall be cross-broken. Unless otherwise stated, ductwork shall be constructed with galvanised sheet steel.

Duct supports shall be at centres needed for rigidity and absence of noise, but in no case more than 2.5 m apart for ducts up to 600 mm wide, and 3 m apart for ducts over 600 mm size. Duct supports shall be of galvanised steel construction.

Suitable spacer shall be provided at support insulated duct to maintain insulation thickness and integrity of vapour seal. Duct supports shall incorporate vibration isolation pads.

Comply with the details shown on the drawings for bends, branches etc. where detail is insufficient and in other cases, bends and branches shall be made of "easy sweep" wherever possible to a curve-ratio of not less than 0.5.

Contractor shall thoroughly clean the supply ducting by rubbing down internally, and vacuuming cleaning out all dust, debris and other foreign materials immediately before balancing and commissioning of the system.

Arrangements for installation of ductwork shall be made in good time before ceiling lining etc. are fixed, and all dimensions, length etc., shall be checked against actual site conditions before fabrication.

Ductwork installed outside the building shall be sealed to water tight. Insulated ductwork outside the building shall be internally insulated.

2.19.1.4 Ductwork Accessories General

Unless specified elsewhere in this specification to the otherwise, the following ductwork accessories shall be provided by the Contractor at locations as specified in the following, irrespective of whether such accessories have been shown on the drawing or not.

a. Fire Dampers - provide fire dampers or fire collars at all duct penetrations through fire rated partitions, floors, and ceilings. Fire dampers shall be of the same or higher than the fire rating as the compartmentation on which damper is installed.

b. Regulating Dampers - provide regulating dampers at the following locations:-
- *i* Branch duct take-off from main distribution duct or distribution plenum.
- *ii* Exhaust outlet, fresh air intake and return air connection of each air handling system
- *iii* Air supply and exhaust grille
- *iv* Duct branch serving one grille; in this case, the grille damper should be omitted
- *v* At all direct driven fan discharge or suction ductwork

c. Test Openings - provide test openings at the following locations:
- *i* Upstream or downstream of regulating dampers. Where possible flow measurement opening shall be located at the shorter side of the straight ductwork and shall be at a distance of not less than five times the shorter dimension of the duct downstream of the damper and any fitting to ensure that the air velocity profile is uniform across the duct section.

  In the absence of such a location in the duct system due of physical constraint, a flow laminator shall be provided upstream of the flow measurement opening.

- *ii* At all fan discharge or suction ductwork

- *iii* Upstream or downstream of all coils.

Provide test openings at no more than 300 mm intervals across the shortest dimension of the duct. Locate opening(s) as close to the mid section of the duct as possible.

d. Access Openings - provide access opening through duct wall at the following locations.

i. Adjacent to all fire dampers so that:-

- Fusible link can be checked or replaced
- The operation of the fire damper can be tested periodically
- Damper can be reopened after closing

ii Adjacent to all duct mounted coils, regulating damper and filter, at no more than 3 metre intervals along the length of duct or between duct obstructions or fittings, for cleaning purposes.

Access openings shall be located at accessible side of the ductwork. Mountings of access doors shall be suitable for externally insulated duct work. Access doors shall be big enough for proper access.

e. Turning Vane and Splitter Damper - provide short chord turning vanes at all square elbows.

Provide splitter damper at all right angles branches from duct to grille.

Provide long chord air turns at round elbow when the turning radius is less than 1½ times the width of the elbow.

All turning vanes at high velocity greater than 10 m/s shall be of aerofoil design.

f. Backdraught dampers - provide backdraught dampers at all duct entry into common exhaust plenum. Air velocity over the backdraught damper shall not be higher than 3 m/s.

g. Air tight dampers - air tight dampers shall be multi-blade type with interlocking trim fitted with silicon gasket.

h. Fire Dampers - fire dampers shall be constructed with galvanised sheet steel of certified fire resistance period of not less than two hours, and certified air leakage rate not more than 2% of the designed air flow rate when subject to air pressure of not less than 1.24 kPa.

Curtain type fire dampers shall be gravity closed when closed vertically and shall be spring closed when closed horizontally.

Blade type fire damper shall be gravity closed.

Damper shall be held in open position by fusible link set for 71°C to 79°C.

Fusible link shall be so arranged that the link shall always be exposed in the air stream. The link holding mechanism MUST NOT interfere with the closing of the damper.

Allow in the tender price for all costs incurred for the Employer to test all fire dampers by actually setting off the fusible link. Provide hot air blower and all ancillaries for the testing.

Unless otherwise specified the type of fire damper to be used shall be Curtain type. Where possible, the clear opening of the fire damper shall equal the air way dimension of the connecting ductwork.

i. Regulating Damper

i. Manual Regulating Damper - manual regulating damper shall be provided with an externally mounted quadrant type locking device. Damper with spindle type multi-turn adjusting rod shall have removable handle at spindle so that adjustment can not be tampered with by an unauthorised persons.

All regulating dampers shall be of rigid construction and shall be installed free from vibration and noise generation during normal operation.

All regulating dampers shall be proprietary units, site fabricated dampers will not be acceptable.

ii. Automatic Regulating Damper - automatic dampers shall be of the balanced type, tight closing with interlocking edges. Where the dampers are used for smoke dampers they shall be the motorised type with spring return. Solenoid type requiring manual reset are not acceptable.

Multi-blade automatic regulating damper shall be opposed blade type.

Multi-blade automatic mixing damper shall be of parallel blade type.

Damper blades in high velocity system shall be of aerofoil design.

2.19.2 Fans

2.19.2.1 General

Fans shall be of a design and capacity capable of maintaining the required air flow volume at the actual system resistance with filters dirty.

Provide certified fan characteristic, power and efficiency curves to Engineer for approval.

Provide fans having noise levels under design output not exceeding those specified. Test certificates of noise level are to be provided before fans are installed.

Provide fans with anti-vibration mounts. All moving parts of the fan shall be statically and dynamically balanced.

Provide fan complete with motor and drive.

Finish all fan castings either hot dip galvanised or two coats red lead primer, undercoat and gloss enamel top coat. A rotation direction arrow shall be painted on the housing fan.

Where mounted on outside wall or roof, fan shall be provided with approved weatherproofing and bird mesh.

2.19.2.2 Centrifugal Fans

Casting shall be of heavy gauge mild steel plate with angle stiffeners and base angles.

Fans are to be quiet in operation and free from drumming. Inspection panels are required only if access to the impeller cannot be obtained through a panel in the ductwork. All impellers and/or shafts shall be capable of convenient removal after installation, and split-casing type fans shall be provided if necessary.

Impellers shall be of mild steel construction with a streamline cast hub of robust design. The blades shall be securely attached to a shroud ring and back plate. The fan impeller and shaft shall be dynamically balanced.

Centrifugal fans shall have motor suitable for variable speed drive operation.

2.19.2.3 Roof Supply/Extract Fans

Supply all roof mounted fans complete with bird protection mesh. Supply all roof extract fans with integral anti-backdraught shutter. Provide speed regulator where specified. All roof extractors shall be curb mounted type. Provide steel ring guard at underside of fan when fan is not duct connected.

2.19.2.4 Vibration Control

Provide all moving equipment with minimum out-of-balance forces. Control vibration amplitude by increasing static mass of vibrating equipment. Isolate vibration by provision of vibration energy absorbing resilient mounting or separation.

Provide constraint to prevent excessive movement of equipment resulting from earthquake or fault conditions.

a. Equipment Isolation from Duct or Pipe

Provide vibration eliminators in the suction and delivery connections to pumps and fans to effectively prevent transmission of vibrations from the equipment to the pipework. Vibration eliminator shall consist of suitably rated flanged cord reinforced rubber or equal approved stainless steel bellows. When possible eliminators shall be installed normal to the direction of vibration.

Pipework shall be rigidly supported on the side of the bellows remote from the vibrating equipment.

Where an in-line pump is directly supported by the connecting pipework, the piping system shall be supported with anti-vibration hangers until no perceptible noise and vibration is transmitted through the pipework.

Provide approved flexible connection between the suction and delivery outlets of fans and their associated ductwork. Support ductwork rigidly on the side of the neoprene coated canvas connector remote from the fan. Allow at least 50 mm axial length between ductwork and fan flanges with the flexible connection 50% longer.

b. Equipment vibration isolation

Isolate moving equipment such as fans, pumps, chillers, cooling towers and condensing units from building structure by anti-vibration devices. The anti-vibration devices shall be selected in accordance with the Selection Guide for Vibration Isolation as published on the ASHRAE Application Handbook.

3 Electrical Requirements

3.1 General

Unless otherwise specified, auxiliary electrical equipment shall conform to all applicable standards of the authorities as specified in 2D.6 Standards. Note that in the Fiji Islands the requirements of the Australian wiring regulations AS/NZ3000:2000 and referenced standards are the paramount requirements.

3.2 System Conditions

System Particulars for 132kV, 33kV & 11kV system applicable in Fiji Islands are stated in the table below:

Normal system voltage	132kV	33 kV	11 kV
System Highest voltage	145kV	36 kV	12 kV
Frequency	50 Hz	50 Hz	50 Hz
Earthing of Neutral point	Directly earthed	Earthed through earthing Transformer	Directly earthed with or without resistor
Design Symmetrical fault level	1000MVA	1125MVA	250MVA
	31.5 kA	31.5 kA	31.5 kA

3.3 Phase Rotation

Generator and motor phase rotation will be designated as R for the 1st phase (U-X), S the 2nd phase (V-Y), and T for the 3rd phase (W-Z). Power phase rotation will be designed as R-S-T. R-S-T type bus arrangements, left-to-right, top-to-bottom and front-to-rear, will be used throughout to assure convenient and safe testing and maintenance.

3.4 Control Equipment Electrical Ratings

3.4.1 Voltage Ratings

Control equipment shall be designed for operation at the following voltages:

- Nominal rating 24-V DC with an operating range of 19.2-V DC to 28.8-V DC, ungrounded.
- Nominal rating 110-V DC with an operating range of 88 to 110 V DC, ungrounded from the station battery.
- Nominal rating 415/240-V AC, 50-Hz, grounded, with an operating range of ±10%.

3.4.2 Electrical Contact Ratings

- Contacts shall be suitable for the application and have current and voltage ratings that will not be exceeded when applied in the control circuits.
- Contacts intended for use in the control circuits shall be electrically-independent, ungrounded, dry contacts, field changeable from "normally-open" to "normally-closed" and have the following ratings:
- Maximum Design Voltage. 415/240-V AC and 110-V DC.
- Continuous Current. 5-A AC or DC.
- Maximum Interrupting Current. Inductive (when L/R≥5000), 1.5-A at 240-V AC and 1.1-A at 110-V DC.
- Maximum Making Current. Inductive (when L/R≥5000), 15-A at 240-V AC and 1.1-A at 110-V DC.

3.5 Motors

3.5.1 Standards

Motors shall comply with IEC 60034 as regards performance and testing. Motors shall comply with AS/NZS1359.5 as regards energy efficiency.

3.5.2 Ratings and Characteristics

- Frequency (AC motors): 50 Hz.
- Voltage (AC motors): 0.75 kW and above, 3-phase, 415V; less than 0.75 kW, 1-phase, 240V
- Insulation: Class B, nonhygroscopic.
- Enclosure: totally-enclosed, fan-cooled, (TEFC) unless otherwise specified.
- Accessories. The following accessories shall be provided:
- Non-ferrous, metal guard screens on all ventilating openings.
- Lifting eyes (eye bolts) on all motors weighing more than 50 kg.
- Space heaters for motors above 50 kW shall be factory mounted in an accessible location under the stator frames and rated to maintain internal temperature approximately 10°C above ambient temperature specified. Heater leads shall be wired to a separate terminal box mounted on the motor. Heaters shall be low watt-density and connected to the motor starter control circuit. Heaters shall be automatically energized when the motor is shut down.
- Ground pads with tapped bolt holes on 2-hole standard centres for motors rated 15 kW and above. Pad locations shall be near the base and shall be shown on manufacturer's motor or assembly outline Drawings.
- Soleplates and hold down bolts, where required.
- Gasketed motor terminal boxes, sized to accommodate external cable and lugs, and suitable for conduit connections. They shall be suitable for rotating in 90º steps.

3.5.3 Service Factor

All motors shall be sized to permit the driven equipment to develop its specified capacity continuously without exceeding the rated temperature and using no more than 85% of rated motor kW capacity (1.15 Service

Factor). The intent of this requirement is that the motor kW capacity be sized above the maximum continuous duty required by the driven equipment.

3.5.4 Bearings

- Bearings shall be liberal in size, suitable for continuous service under the conditions specified, sealed against the entrance of dirt and the escapement of the lubricant.
- Fitted openings shall be provided on the bearing housing for applying and draining the lubricant. Filler and drain extensions shall be furnished where necessary to give ready accessibility.
- Wherever necessary, the bearings shall be insulated to prevent the passage of shaft currents through the bearings.
- The thrust bearing for vertical motors shall be of the antifriction type, capable of supporting the weight of the motor and driven equipment rotating parts plus hydraulic thrust due to load. Bearings shall be grease lubricated with provisions for greasing. Provisions shall be made to prevent over-greasing where excess lubrication may cause damage.

3.5.5 Starting

- Except where specifically indicated otherwise, motors shall be suitable for full-voltage, across-the-line starting.
- Motors shall accelerate the driven equipment to rated speed with 80% of the motor nameplate voltage applied at the terminals. Unless otherwise approved, the maximum starting current shall not exceed 6 times the rated full-load current.
- Motors shall withstand without adverse effects, a full voltage, dead-bus transfer from one source to another. The minimum "dead time" for this transfer shall be considered to be 1 second.
- Where repetitive starting is necessary, the permissible number of starts shall be clearly indicated on the nameplate.

3.5.6 Finish

Motors for use indoors shall have the manufacturer's standard finish unless otherwise specified. Motors for outdoor use shall have corrosion-resisting hardware and corrosion-resisting finish on the rotor and shaft.

3.6 Cabling Installation Practice

3.6.1 General

All cables shall be run parallel to walls and either truly vertical or horizontal as appropriate. Agree all exposed cable routes with the Engineer prior to commencing work. All holes through structural members shall be approved by the Engineer before drilling commences.

Ensure that all cables are supported to avoid undue strain on cables or on terminations. All cabling shall be neatly dressed, run in single layers and identified as to function at terminating points. All cabling shall be installed in a manner which permits its convenient withdrawal and replacement. No cable shall be cast directly into concrete.

Sharp edges to steel or sheet metal shall be removed and such work shall be arranged to avoid accidental injury to personnel, or damage to insulation. Provide insulated bushes at all points where cables enter metal enclosures.

3.6.2 Cable Identification

Each cable shall be labelled with a permanent identification number as indicated on the Contractors cable schedules. All cable cores shall be numbered.

3.6.3 Underground Cables

All underground cables are to be buried in a trench at a minimum depth of 600mm, bedded on not less than 100mm of fine washed sand and covered by a further 100mm of sand. The cables are to be laid free of kinks and twists and laid in flat formation without interlacing.

The trench shall be backfilled with 150mm of soil, consolidated and a protective layer of 150 x 25 RS ground retention tanalith treated timber, or approved proprietary cable protection covering is to be placed over the full length of the trench.

Cabling is to be completed covered by timber or equal protection.

Lay on Orange PVC signal strip 100mm wide with "Electric cable below" or equal labelling, above cables over fully length of route, at a depth of 250mm. Locations of underground cables are to be accurately marked on the Contract drawings. Where underground cables enter building a warning sign indicating "danger buried cable" is to be fastened to the building 200mm above ground level.

3.6.4 Cable Ladder

Provide all necessary cable ladder to support cables. All cable ladder width shall be sufficient for the work plus 30% spare capacity.

Cable ladder shall be manufactured from aluminium and shall be of NEMA 12A type. Cable ladder shall be stood off the wall on galvanised spacers or brackets or suspended from the ceiling on purpose made angle iron brackets galvanised after fabrication. Maximum spacing of supports, brackets and hangers shall be 2 meter. Cable ladder shall be capable of supporting 12.5 kg/m per 100mm, i.e. a 600mm wide cable ladder must be capable of supporting 75 kg/m.

All runs of ladders shall be continuously bonded and earthed.

For all HV cabling, proprietary cable clamps must be used.

Ladders shall not be mounted directly onto flat surfaces. Install on suitable brackets clear of the surface to allow for cleaning and sufficient space for air circulation around and through the ladders.

3.6.5 Cable Installation Practice (HV Cables)

i General

Single core cables shall be laid in trefoil formation using approved trefoil clamps at intervals of no more than 1m. All cables shall be pulled, supported and terminated in accordance with manufacturer's instructions.

All copper wire screens and steel wire armour shall be bonded and earthed at both ends.

Joints in cable runs shall not be permitted (except for the aerial bundled conductor line).

All exposed cables shall be run parallel to walls and either truly vertical or horizontal as appropriate.

Cables to transformers may be supported as necessary using galvanised saddles fixed to the equipment frame but on no account shall penetrations be made in tanks containing oil.

ii Terminations

At termination boxes cables shall be glanded. All terminations shall use compression terminals.

The Contractor shall ensure that:

a. All cables shall be glanded using stainless steel glands incorporating a waterproofing seal. All terminations shall use pressure crimp lugs, compressed using the correct tool.

b. Glanding and termination of cable is carried out strictly in accordance with manufacturer's instructions.

c. All bolts used in termination shall be stainless steel fitted with plain washer and two nuts. The torque of all bolted connections for cables over 70mm2 shall be recorded.

d. PVC shrouds are fitted to outdoor cables and/or that any future creepage will not leave armouring exposed.

e. Two locknuts are fitted to each gland and that each gland is fitted to a gland plate or bracket.

f. Bushes are fitted on each gland.

g. Cable glands and cable sheaths are effectively connected to the earthing system. Earth connections must have a cross section not less than 50% of the cross section of a core of the associated cable.

h. Under no circumstances shall copper and aluminium conductors be directly connected.

3.6.6 Cabling Installation Practice (LV Cables)

i. General

All exposed cables shall be run parallel to walls and either truly vertical or horizontal as appropriate. Cables shall be run on either cable ladder or floor ducts as appropriate.

Cables shall be sized to achieve a voltage drop of less than 2.5% of the nominal voltage between the distribution board and fitting. The maximum voltage drop from the station services transformers to the final sub circuit shall be no more than 5%.

Ensure that all cables are supported to avoid undue strain on cables or on terminations. All cabling shall be neatly dressed, run in single layers and identified as to function at terminating points. All cabling shall be installed in a manner which permits its convenient withdrawal and replacement. No cable shall be cast directly into concrete. In such areas install cables in conduit or ducting. Draw wires shall be installed in conduits or pipes where necessary for later cable installation.

Sharp edges to steel or sheet metal shall be removed and such work shall be arranged to avoid accidental injury to personnel, or damage to insulation. Provide insulated bushes at all points where cables enter metal enclosures.

After installation but before connection, all power cables shall be tested for insulation resistance.

Cabling shall be cleated at centres not exceeding:-

: 450 mm horizontally
: 900 mm vertically

On no account shall plastic sheathed cables be run in any situation where timbers have been treated or likely to be treated with tar-oil, creosote or allied products.

No ordinary grade PVC insulated cables shall be run in any location where the temperature is likely to exceed 45^{o}C. No high temperature grade PVC shall be run in locations where the temperature is likely to exceed 75^{o}C. Mineral insulated cable shall be used where the temperature may exceed 75°C.

Wiring which supplies equipment liable to overheat and cause rapid deterioration of the wiring, shall have the tails made off with heat resisting sleeves to protect the permanent wiring in a conduit box. The conduit box shall be fitted with terminals and mounted adjacent to the fitting or equipment with a run of heat resistant cabling from the box.

3.6.7 Cable Installation Practice (Instrumentation Cables)

The following installation practice shall be used:

Cable shields shall be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, an insulated point on the terminal block shall be used for connecting the shields.

Shields shall be isolated and insulated except at their selected grounding point to prevent stray and multiple grounds to the shield.

At the point of termination, the shield shall not be stripped back any further than necessary from the terminal block.

For signal circuits, the shield must not be part of the signal circuit.

Signal circuits shall be grounded at only one point.

Digital signal circuits shall be grounded only at the power supply.

Analogue signal circuits shall be grounded only at the control panel and on a clean earth.

Analogue signal cables shall be physically segregated from all power and control cables and from unshielded cables carrying digital or pulse type signals.

3.7 Cable Selection

3.7.1 240/415V Cables

Cables shall be a minimum of 600/1,000 volt rating for 415 line voltage use.
All low voltage power cables shall have stranded copper conductors, shall be installed in accordance with AS/NZS 3000 and shall be rated in accordance with AS/NZS 3008.1.2..
Cables shall comply with the following standards:-

PVC insulated	:	NZS 6401
	:	AS/NZS 4961
	:	AS/NZS 5000.1
XLPE insulated	:	AS/NZS 5000.1
	:	AS/NZS 4026
	:	AS/NZS 4961
Neutral Screened	:	AS/NZS 3155

3.7.2 Instrumentation Cabling

Type.	Twisted pairs or triads (RTD's) with an overall shield.
Conductor	Stranded, tinned copper, 0.5 mm^2 or larger.
Insulation Type	PVC
Rated Voltage (not less than)	150V DC
Continuous operating temperature	105°C (dry)

The insulated conductors shall have an overall aluminium foil shield bonded to a mylar or polyester film with a stranded, tinned copper, continuous drain wire outside of the shield.

Each pair/triple wire shall be marked with indelible numbering.

3.7.3 Control Cabling

Type	Unarmoured, circular, multicore with an integral earth conductor.
Conductor	Stranded, copper, 1.5 mm2 or larger.
Insulation Type	PVC
Rated Voltage (not less than)	1000-V AC
Continuous operating temperature	90°C

Each core shall be marked with indelible numbering.

3.8 Earthing and Equipotential Bonding

Effective protective earthing and equipotential bonding shall be provided, in accordance with the Fijian Electricity Act and AS/NZS 3000, for all electrical equipment installed under this contract. The Contractor must ensure all metal work encasing electrical work is bonded to earth. This shall include bonding all trays, ladders, trunking and electrical equipment.

3.8.1 Building Structure

The building structural reinforcing, metal cladding, metal roofing, metal doors, hand railing and supporting steel work shall be securely bonded. Connections to the building reinforcing are to be made at 5m intervals. Connections to the foundation reinforcing must be made via a copper strip brazed to the reinforcing.

3.8.2 External Foundation Pads

Earthing of reinforcing of small external foundation pads of size less than or equal to 2 x 2m is not required. However, steel reinforcing of larger pads shall be bonded with the earth mat at two points to provide equipotential bonding.

3.8.3 External Fencing

All metallic fence supports and wire mesh shall be securely bonded. Each section of the fence shall be earthed using 16 x 2.5mm copper strap and long sections of the fence shall be earthed at intervals not greater than 20m. Earthing terminals shall be provided on metal fence posts by welding a lug with 2 x 14mm dia. holes at 50mm vertical centres. The lug shall be located on the inside of the fence.

3.9 Panel Construction

3.9.1 Metalwork

All enclosures used to house electrical equipment shall be gasketed, vermin proof and protected to the class specified in accordance with AS/NZS IEC 60947-1. The maximum height above floor level of all instruments, control switches and relays shall allow for easy operation of the plant and shall not exceed 1.80 m.

Enclosures shall consist of rigid, self-supporting, steel panels with a minimum thickness of 1.5 mm steel that have full-length, hinged and gasketed doors, located to provide easy access to the equipment. A tamper-proof lock shall be provided on each door of the enclosure. Interior panels shall be provided inside the enclosures for mounting items of electrical equipment.

All panels shall be located on a 75mm high plinth made of steel or concrete, as applicable to the general construction.

Panels inside a switchroom or other outdoor enclosure that affords the same protection as a switchroom may be made of coated mild steel sheet construction. Steel shall be passivated, powder coated finished with baked enamel paint.

Panels housed within an outdoor weatherproof enclosure shall be multi-compartmented with a compartment for each functional unit.

All fastenings shall be integral with the panel or door and provision made for locking. Doors shall be rigid and fitted with weatherproof sealing material suitable for the climatic conditions specified. No door shall be wider than 1200mm without the permission of the Engineer. Panel positions in general and door sizes and positions when open, shall not impinge on the safety and operability requirements of these clauses.

Outdoor panels shall be well ventilated through vermin-proof louvres comprising a filter screen attached to a frame and secured to the inside of the panel. Divisions between compartments within the panel shall be perforated to assist air circulation. If required, ventilation fans shall be used.

3.9.2 Terminals

Panel, including all terminations and other current carrying parts shall have a minimum IP rating of 2X with the panel doors open.

All terminals shall be mounted in accessible positions. Adjacent terminals shall be adequately spaced to each other and to the incoming cable gland plate. Separate terminations shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.

All terminals having a circuit voltage of 240V or higher shall be separated from lower voltages by a space created with partitions or end plates combined with end brackets and shall be shielded with an insulated cover marked with a warning notice "Danger ..... Volts". Where necessary, the different 240V / 415V phases shall be shielded from each other with partitions (i.e. where the in-service or under-maintenance breaking of a phase-wire can result in a phase to phase short circuit due to the type of terminal used).

Terminal blocks shall not be located less than 200mm from cable gland plates.

Only one conductor shall be terminated in each side of the terminal block.

Shorting straps shall be used between terminal blocks to bridge identical conductor terminals.

Cubicles shall have at least 10% spare terminals and enough extra space on mounting bars for another 20% terminals.

3.9.3 Neutral & Earth Bars

These shall be a generous size to enable convenient termination of all neutral and earth conductors.

Neutral and earth bars shall be provided with purpose made terminations sufficient for all connections with 25% spare. The bars shall be brass, tunnel type with slotted grub screw termination fixing and shall be rated at not less than the full current carrying capacity of the main supply. Terminations are to be provided for incoming neutral and earth cables of sizes shown on the drawings or as required by AS/NZS 3000.

Busbars and connected circuits shall be capable of carrying continuously a total load equal to the rated capacity of the incoming switch isolator without the temperature rise of any component mounted with or on a board exceeding 20°C.

The earth and neutral bar shall be located well clear of incoming cables and other connections.

3.9.4 Busbars & Connections

Busbars and connections thereto shall be fully insulated and shall comply with AS/NZS 3439.2.

Busbars shall be capable of carrying the continuous rated current with a maximum temperature rise of 30°C above an ambient temperature of 40°C.

Clearances are to be maintained when a current equal to the specified short circuit rating is flowing in the busbars and connections and shall be capable of withstanding the specified test voltages. Busbars shall be rated at not less than the maximum current rating as indicated on the drawings and braced to withstand fault levels, which can be safely cleared by the section isolators.

3.9.5 Fuses

Fuses shall be high rupturing capacity and type gG as defined in IEC 60269-1, IEC 60269-2-1 and have minimum breaking capacities equal to 80kA or greater. Fuses to be used for motor protection may be type aM.

In any case fuses shall have a minimum interrupting volt-ampere capacity at least equal to the fault rating at the switchboard specified herein.

Fuse ratings and the phase to which they are connected are to be legibly marked on holder and base. Provide (6) spare fuse links of each size and type used on the switchboard and locate in a purpose made compartment. Provide all spare fuse bases as indicated.

3.9.6 Miniature Circuit Breakers (MCBs)

Miniature circuit breakers (MCBs) shall be the trip-free type category "C" with instantaneous release under heavy fault conditions. They shall comply fully with AS/NZS 60898.1 and be mounted to be removable without removing adjacent circuit breakers.

Circuit breakers shall have a fault rating of not less than the fault level of the distribution system at the point of connection in the switchboard but not less than 10kA.

A minimum of 25% spare ways shall be provided to allow for the future MCBs.

3.9.7 Moulded Case Circuit Breakers (MCCBs)

Moulded case circuit breakers shall comply with AS/NZS IEC 60947-2.

The ultimate breaking capacity of the circuit breakers shall be at least equal to the prospective fault level at the point of the distribution system where the breakers are installed.

The service breaking capacity shall be 100% of the ultimate breaking capacity.

The breakers shall be operated by a toggle, which shall clearly indicate the three fundamental positions ON and OFF and TRIPPED.

For breakers up to 250A, each MCCB shall be fitted with an interchangeable trip unit incorporating a bi-metallic element for overload protection and magnetic protection for short-circuit. MCCBs above 250A shall be provided with an interchangeable electronic trip unit. In all cases a range of adjustable settings shall be provided on the trip unit.

3.9.8 Relays

All relays are to be of best quality with contacts rated for a continuous duty of not less than 10A. They shall be encased in hermetically sealed enclosures and shall be free from discernible noise when energised. Auxiliary contacts are to be self-cleaning.

3.9.9 Contactors

All contactors are to be of best quality with contacts rated for a continuous duty of not less than 16A. They shall be free from discernible noise when energised.

3.9.10 Isolators

Every functional unit shall be provided with effective means of isolation.

All live side terminals of these isolators shall be shrouded to prevent accidental contact.

Isolators shall be rated for the continuous load current and for the maximum fault duty, which may be reached. Isolators shall not be smaller than sizes shown on the drawings.

Isolators shall be capable of being locked in the open or closed position. Isolators shall comply with AS/NZS IEC 60947-3 for AC 23 duty.

3.9.11 Pushbuttons and Pushbutton Switches

i. Type

Pushbuttons and pushbutton switches shall be heavy-duty, oil-tight, complete with engraved legend plates, operators, and contact blocks. Legend plate engravings shall be selected by the Contractor and will be subject to the Engineer's approval.

ii. Contact Ratings

- Maximum Design Voltage. 500/300-V AC and 110-V DC.
- Continuous Current. 10-A AC or DC.
- Maximum Interrupting Current, Inductive. 3-A at 240-V AC and 2.2-A at 110-V DC.
- Maximum Making Current, Inductive. 30-A at 240-V AC and 2.2-A at 110-V DC.

3.9.12 Control and Selector Switches

i. General

Manually-operated switches provided and mounted on the front of switchboards and control cubicles shall be as specified herein.

ii. Type

Switches shall be heavy-duty, rotary type complying with the requirements of AS/NZS IEC 60947-5-1 for AC 11 duty.

Ratings

Maximum Design Voltage.	500/300-V AC and 240-V DC.
Continuous Current.	10-A AC or DC.
Maximum Interrupting Current, Inductive.	3-A at 240-V AC and 2.2-A at 110-V DC.
Maximum Making Current, Inductive.	30-A at 240-V AC and 2.2-A at 110-V DC.

iii. Escutcheon Plates

Each switch shall be provided with an escutcheon plate clearly marked to show each operating position. Escutcheon plate markings shall be selected by the Contractor and will be subject to the Engineer's approval.

iv. Handles
The type and colour of the switch handle shall be selected by the Contractor and will be subject to the Engineer's approval.

3.9.13 Electrical Digital and Analogue Indicating Instruments

3.9.13.1 Type and Construction

Instruments shall be of the flush mounting type with non-reflecting glass. They shall be calibrated and suitable for the application. Electrical measuring instruments generally shall be 96 x 96 mm but may be 72 x 72 mm if approved by the Engineer. Analogue instruments shall be of the 270° full-scale deflection type.

Digital instruments shall have the following features:
- Bright orange LED display.
- Minimum 4-digit, 12 mm-high, readout.
- Black bezel with hardware and accessories for front-of-panel mounting.
- 1% accuracy

i. Standards
Indicating instruments shall conform to IEC 60051, class index 1.5.

ii. Scale Markings
Scale markings shall be selected by the Contractor and will be subject to the Engineer's approval. Where instruments are connected to instrument transformer secondaries, the scale markings shall be selected to read the electrical quantities on the transformer primary.

3.9.13.2 Transducers and Transmitters

Transducers and transmitters shall be suitable for accurately measuring the specified quantities. Outputs shall be a dc current signal ranging from 4 to 20-mA full scale, suitable for termination in a load resistance up to 750Ω.

Unless specified otherwise, the maximum allowable error shall not exceed ±0.25% of full scale at 25°C, and the error resulting from a temperature variation between -20°C and 60°C shall not exceed ±0.5% of full scale. AC output ripple shall not exceed 1%. The units shall be provided with a 10% full scale calibration adjustment, and the response time shall be 400 ms or better from 0 to 99%. There shall be electrical isolation between input, output, external power supply if used, and the case ground connection. All transducers and transmitters shall have a dielectric test voltage rating conforming to IEC SWC test requirements.

3.9.13.3 Indicating Lamps

i. Type
Lamps shall be light emitting diode (led) type, 22.5mm diameter with press to test facility.

ii. Ratings

The indicating lamps and resistors shall be rated to operate at 240-V AC or 24-V DC.

3.9.14 Motor Starters

Low voltage motor starters shall be of the combination type as defined in AS/NZS IEC 60947 - Part 4 and shall comprise:

- Fused combination unit (disconnector and fuse switch) or moulded case circuit breaker (AC23 minimum utilisation category).
- AC contactor (AC3 minimum utilisation category).

The operating mechanism of the isolating device shall be mounted on the front of the cubicle, operated by a pistol grip type handle. The mechanism shall be interlocked with the door to prevent opening when in the on position. The mechanism shall be padlockable in the off position.

The rated operational current of the starter (Ie) shall be not less than the full-load current of the motor. The starter shall be rated for uninterruptible duty.

Thermal overload relays shall be Type 3c as defined AS/NZS IEC 60947-4-1. Time/current characteristics shall be supplied, by the manufacturer, on 28mm x 56mm logarithmic decades. These curves shall have a tolerance not exceeding + 10%.

Co-ordination of short circuit and overload protective devices shall be type 2 fully co-ordinated as defined in AS/NZS IEC 60947-4-1 for a prospective short-circuit current not less than the value determined by the electrical system design. For this purpose the short circuit protection device shall be fitted with the maximum rating of motor circuit fuse.

Motor starters shall be suitable for both automatic and non-automatic methods of control.

Unless otherwise specified, motor starter control circuits shall be operated from a 24V AC supply, derived from an individual, integral starter control transformer.

Power factor correction capacitors shall be provided in motor starters to correct the motor power factor to a minimum of 0.93. Separate contactors shall be used to switch the motor circuit and power factor correction equipment.

Where assisted start motor starters are required in order to reduce motor starting currents, electronic soft start units shall be used. Electronic soft start units shall be provided complete with bypass contactor. Assisted start operation shall be automatic changeover with adjustable time delays to suit the motor conditions.

Contactors shall be provided with auxiliary contacts to provide all required control and signalling functions and shall be provided with two additional spare normally open and two spare normally closed contacts.

Each starter shall be provided with the following controls and indications as a minimum:-

- Door interlocked isolator.

- Running lamp.
- Stopped lamp.
- Fault lamp.
- Run/off/auto selector switch,
- Auto-control interposing relay 24V DC operated from plant control system.
- Plant trips relay 24V DC operated from plant control system.
- Ammeter.
- Hours run meter.
- Number of starts counter.
- Emergency stop pushbutton.
- Trips reset pushbutton.
- Lamp test pushbutton.

Each starter shall be provided with the following volt free contacts to provide interface with the plant control system:-

- Running/stopped.
- Machine available for auto control.
- Fault.

Each starter shall be provided with a test facility, which shall energise the control circuit when operated. The test switch shall be arranged to automatically release when the starter door is closed. The test facility shall enable the control circuits to be operated for testing purposes with the main motor circuit isolated.

Each starter shall be provided with the facility to disconnect the controls via a remote emergency stop pushbutton. Where a pushbutton is not installed the connection facility shall still be provided, but linked out. All emergency stop operations shall require resetting by the starter/drive reset pushbutton to restart the machine.

Each starter shall be provided with the facility to disconnect the controls via a remote early break contact on an isolator located adjacent to the motor.

Where a motor is supplied with auxiliary protective devices (e.g. thermistor protection or moisture protection), the protective relays and associated controls shall be incorporated into the design of the starter.

Control circuits shall be provided with a power on delay timer which shall make the starter available for automatic or manual control on restoration of the power supply without requiring operation of the reset pushbutton, unless another fault condition exists.

Where a motor is supplied with an anti-condensation heater, an on/off switch shall be provided on the front of the starter to isolate the heater. The heater shall be switched via an auxiliary contact on the main contactor, operating so that the heater is energised whenever the motor is off.

3.9.15 Heaters

Enclosures containing electrical control and switching equipment shall be equipped with electric space heaters for moisture control. The construction of the enclosures and the placement of the heaters shall assure effective circulation of air and prevent damage to equipment by overheating. Heaters shall be rated 240-V AC, single-

phase. They shall be provided with thermostatically operated controls with "on-off" switches mounted inside the enclosure.

3.9.16 Lighting and Receptacles

Enclosures larger than 1.0 m^2 (vertical, front-of-panel surface area) shall be provided with a light and receptacle inside the enclosure to facilitate operation and maintenance. The light shall be incandescent type, with wire-guard and "on-off" switch. The receptacle shall be a duplex type, 2-pole, 3-wire. Power supply to the light and receptacle will be from a single-phase, 240-V AC, circuit.

3.9.17 Panel Wiring

All panel wiring shall be carried out in a neat and systematic manner with cable supported clear of the panels and other surfaces at all points to obtain free circulation of air.

All PVC insulated panel wiring shall comply with the requirements of BS 6231 Type BK. Conductors shall generally have a minimum cross section equivalent to 3/0.77mm (1.5mm^2), 7/0.67mm (2.5mm^2) but single stranded conductors should only be employed for rigid connections which are not subject to movement or vibration during shipment, operation or maintenance.

Wire colours shall be as follows:

415V AC	Red	A-phase connections in current and voltage transformer circuit only
415V AC	White	B-phase connections in current and voltage transformer circuits only.
415V AC	Blue	C-phase connections in current and voltage transformer circuits only
415/240V AC	Green with Yellow stripes	Connections to earth.
415/240V AC	Black	AC neutral connections, earthed or unearthed, connected to the secondary circuits of current and voltage transformers
240V AC	Red	Single phase AC connections other than those above

	Positive	Negative
24V DC	Grey	Pink
12V DC	Purple	Pink
Current Loops	Purple	Pink

24V AC	Brown	Phase wires
24V AC	Orange	Neutral wires

Provide segregation between LV and ELV outgoing terminals.

Wiring to doors shall be anchored at the panel side and sufficient length shall be provided to enable the door to swing fully open without strain on cabling.

All wiring shall be identified with slip on ferrules with indelibly printed letters and numbers.

All outgoing control / controlled field wiring shall be brought out to terminals to facilitate ease of termination. Termination of all wiring at these terminals shall be effected using pre-insulated crimped ferrules or lugs of the correct size to suit cable and terminal capacity.

No wires may be teed or jointed between terminal points.

Electrical wiring and instruments shall be so located that leakage of oil or water cannot affect them.

Bus wiring between panels, cubicles, etc, shall be fully insulated and be completely segregated from the main panel wiring.

All metallic cases of instruments, control switches, relays, etc, mounted in panels, steel or otherwise, shall be connected by means of green with yellow stripes PVC insulated copper conductors of not less than 2.5mm² cross section to the nearest earth bar.

3.9.18 Panel Earthing

All metallic cases of instruments, control switches, relays, etc, mounted in panels, steel or otherwise, shall be connected by means of green with yellow stripes PVC insulated copper conductors of not less than 2.5mm² cross section to the nearest earth bar.

All metalwork shall be bonded to the main earth bar. All hinged panels shall be bonded with flexible copper.

All cable sheaths and earthing conductors shall be bonded to the earth bar. Use compression type conductor lugs for all earth connections with bolted joints. Ensure that all connections are tightened.

Earth continuity shall not depend upon metal joints. For panel earthing use starred washers between screw and panel.

3.9.19 Panel Labelling

All panels shall be fitted with an identification/rating plate displaying the following information: site name; rated voltage, phasing, frequency, current, etc; panel/equipment manufacturer; and contract number.

All items, including exterior items, shall be identified with a white engraved laminate label with black lettering. All panel labels shall be fixed by two cadmium plated or stainless steel screws.

The requirement for labels includes, but is not limited to, the following:

- All panels, boxes, cabinets, cubicles or enclosures.

- Equipment mounted in or on the above items including relays, contactors, starters, sounders, motors, switches, sockets, controllers and luminaires.

3.10 Small Power requirements

3.10.1 Outlet Boxes

Each fixture or continuous row of fixtures and all switches, receptacles, and other wiring devices shall be provided with suitable outlet boxes. Boxes for use in dry locations shall be constructed of galvanized sheet steel. Covers shall be held in place with stainless steel screws. Boxes located outdoors shall be cast metal or alloy, fitted with screw-fastened covers and gaskets and with threaded conduit connections. Outlet box extension rings shall be provided for exposed conduit extensions from embedded outlet boxes. Extension rings shall match the embedded boxes. Where extension rings are mounted on cast type boxes, neoprene gaskets shall be used.

3.10.2 Receptacles and Switches

Duplex receptacles shall be 3-wire, grounding type, rated 20-A, 240-V AC, with ground connection wired to separate ground conductor in raceway.

Switches used for the control of lighting fixtures shall be rated 20-A, 240-V AC, single-pole, two-pole, 3-way, or 4-way, as required.

Wall switches and receptacles shall be covered with device plates suitable for the type and number of devices enclosed. Covers mounted on boxes containing 2 or more devices shall be of the combination type. Device plates shall be stainless steel in all indoor, dry locations. Device plates for duplex receptacles installed outdoors shall be provided with spring-type gasketed covers.

Power outlets shall consist of one single gang receptacle integrally mounted with a safety switch. The safety switch and receptacle shall be interlocked so as to prevent the insertion or removal of a plug from the receptacle with the switch in the "ON" position. Both the switch and the receptacle shall be rated 415-V AC, 100 A. The safety switch shall be a heavy duty 3-pole switch with visible blades and a quick make-and-break mechanism. The receptacle shall be 3 phase, 4 wire grounded through the extra pole and shell.

Power receptacle plugs shall be for 100-A service.

3.10.3 Fixtures

Fixtures shall be furnished complete with mounting brackets, fixture mounting stems, poles, or hangers, together with steel supports and/or channels as required, and fixture wires. All fixtures shall be subject to approval by the Engineer.

3.10.4 Ballasts

Ballasts shall be provided with fixtures as required and have a high power factor and shall be of required voltage and frequency.

3.10.5 Lamps

Lamps shall be furnished for all lighting fixtures. Lamps shall be of the required type, length, and wattage.

3.10.6 Lighting Panel Boards

Lighting panel boards shall be rated 415/240-V, 3-phase, 4-wire, 50 Hz, with 200-A (minimum) main bus and shall be provided with 3-pole main circuit breaker and 42 single-pole, 20-A branch circuit breakers.

Each lighting cabinet shall consist of a panel board, box, and cover together with main circuit breaker, branch circuit breakers, buses, and other accessories as specified herein. They shall be of dead front construction. All lighting panel boards shall be the product of the same manufacturer and shall be completely built, assembled, and tested in the factory.

3.10.7 Lighting Contactor Cabinets

Lighting contactor cabinets shall be provided for manual/automatic control of outside lighting. The cabinets shall be furnished with all required equipment to make the installation complete.

3.10.8 Photocells

Photocells shall be furnished as required.

3.11 Switchboards

The Contractor shall submit layout and manufacturing drawings for all switchboards for review by the Engineer. The Contractor shall receive the Engineer's comments before manufacture commences. The Contractor shall include all reasonable alterations required by the Engineer.

3.11.1 General

Switchboards are that part of the electrical installation as defined by AS/NZS3000. Switchboards may include control panel sections and distribution board sections. Control panel sections and distribution board sections shall be built to the same panel standard as the switchboard in which they are mounted. Distribution boards within switchboards shall otherwise agree with the Distribution Board section that follows.

Assemblies shall be designed and built to comply with the following standards:

AS/NZS IEC 60947: Low-voltage switchgear and controlgear assemblies.

3.11.2 Metalwork

Panels shall be of rigid sheet metal construction and the minimum thickness of the sheets employed shall be 1.5 mm. The front of the panels shall have a smooth well-finished surface.

Panels mounted indoors shall, as a minimum, be manufactured from coated mild sheet steel. The steel shall be passivated, powder coated and finished with baked enamel paint. Colour to be confirmed by Engineer.

3.11.3 Construction

Switchboards shall be cubicle types, flush front switchboard accommodating all equipment shown on the drawings and described herein.

- Switchboards shall be Form 3a as a minimum.
- Switchboards shall be IP 42 as a minimum.

Switchboards shall be built up out of welded mild steel framework, fitted with removable sheet metal covers. Alternatives based on proprietary bolt-together frame-systems are subject to the approval of the Engineer.

Steel covers shall be made from minimum 1.2mm material. All metal work shall be bonded to the earth bar.

All connections shall be capable of being terminated without disconnecting other items and shall provide sufficient room for all required cable turns without exceeding cable minimum "during installation" and "set" radiuses as appropriate in each case. The switchboard shall have a separate steel-channel mounting base in a continuous length drilled for fixing to the floor with 10 mm diameter bolts.

No door shall be wider than 800mm without the permission of the Engineer. Also refer to AS/NZS 3000 clause 2.9.8 "Location of Switchboards" and clauses 2.9.9 and 2.9.10. Panel positions in general and door sizes and positions when open, shall not impinge on the safety and operability requirements of these clauses.

Starred washers shall be used to provide earth continuity between adjacent steel surfaces.

Provide all necessary ventilation to ensure that heat build-up does not occur. Panels shall be well ventilated through vermin-proof louvers comprising a filter screen attached to a frame and secured to the inside of the panel. Divisions between compartments within the panel shall be perforated to assist air circulation, but not if this negates the section isolation requirements of AS/NZS 3439. If required to achieve satisfactory operating temperatures, thermostatically controlled ventilation fans shall be used.

3.11.4 Busbars and Connections

The main busbars shall be rated as required and braced to withstand fault levels as specified or 22kA rms for 1s, whichever is the larger. The busbar system shall be capable of withstanding thermal and magnetic stresses consistent with AS/NZS 3439.

Busbars and connections thereto shall be fully insulated. Clearances shall be maintained when a current equal to the specified short circuit rating is flowing in the busbars and connections, and must be capable of withstanding the specified test voltages.

Bolted links shall be provided to allow for easy replacement of all current transformers.

The design of busbars shall permit convenient future extension of the switchboard. Busbars shall be drilled, shall be copper and shall be fully tinned.

3.11.5 Neutral & Earth Bars

Neutral and earth bars shall be generously sized to enable convenient termination of all neutral and earth conductors. Busbars and connected circuits shall be capable of carrying continuously a total load equal to the rated capacity of the incoming switch isolator (or circuit breaker) without the temperature rise of any component mounted within or on a board exceeding 20°C.

Neutral and earth bars shall be provided with purpose made terminations sufficient for all connections with 25% spare. The bars shall be brass, tunnel type with slotted grub screw termination fixing. Terminations shall be provided for incoming neutral and earth cables of sizes shown on the drawings or as required by the Regulations.

3.11.6 Moulded Case Circuit Breakers (MCCBs)

Moulded case circuit breakers shall comply with AS/NZS IEC 60947-2.

The service breaking capacity (Ics) shall be 100% of the ultimate breaking capacity (Icu). The rated ultimate breaking capacity (Icu) of each moulded-case circuit breaker shall be equal to at least the value of the short-circuit current (Isc) at the point of installation on the electric circuit, unless the upstream circuit breaker makes it possible to ensure coordination as defined in Appendix A of AS/NZS IEC 60947-2.

All MCCBs shall be designed for horizontal or vertical mounting without any adverse effect on electrical performance. It shall be possible to reverse feed the breaker without reduction in its performance.

MCCBs shall be available in fixed, plug-in or withdrawable models and in 3 pole or 4 pole versions.

MCCBs shall be of circuit breaker disconnector type.

The breakers shall have a rated operational voltage of 690V AC (50/60Hz).

The rated insulation voltage of the circuit breakers shall be 750V AC (50/60Hz).

The MCCBs shall provide class II insulation (to IEC 664) between the front and internal power circuits.

The operating mechanism shall be of the quick make quick break type, with the speed of operation independent of the operator, and shall be trip free.

The breakers shall be operated by a toggle or a handle as specified which shall clearly indicate the three fundamental positions ON, and OFF and TRIPPED. If required, rotary handles shall be fitted to the breaker.

MCCBs of the same range shall have a common depth.

The operating mechanism shall be designed in such a way that the position of the operating handle of the circuit breaker indicates the real position of the main contacts (i.e. positive contact indication), even if the circuit breaker is equipped with a rotary handle.

Isolation shall be provided by a double break on the main circuit.

It shall be possible to lock the circuit breaker in the isolated position only with the use of a locking device and padlocks.

MCCBs shall have clearly accessible from the front face:

- Markings of rating
- Marked as suitable for isolation
- Push-to-trip test button to test operation of poles
- Contact position indicator

The MCCB shall provide double insulation of the front face to allow on-site installation of auxiliaries without de-energising the installation or circuit. All electrical auxiliaries and accessories including voltage releases (shunt or under-voltage) and auxiliary contacts shall be designed for easy on-site installation. All electrical auxiliaries shall be equipped with terminal blocks and shall be of the snap-in type. All electrical auxiliaries shall be separated from power circuits and their addition shall not increase the MCCB volume.

It shall be possible to fit the MCCB with a motor mechanism without affecting the circuit breaker characteristics.

3.11.6.1 Protection Function

Each MCCB shall be provided with an integral trip unit that shall be easily interchanged with standard tools. The trip-setting area shall be able to be sealed off.

All MCCBs shall include the option of, or be fitted standard with, an electronic trip unit. These shall be true RMS sensing and shall withstand temperatures of up to 125°C.

For MCCBs up to and including 250A rating, standard trip units may be thermal-magnetic types, with at least 36 long-time current adjustments and pre-set short-time and instantaneous tripping. The optional electronic trip units shall provide as a minimum :

- Long-time protection with 48 current threshold adjustments
- Short-time protection with 8 current threshold adjustments
- Pre-set instantaneous protection
- 40A, 80A, 100A, 160A and 250A protection units.

For example, the 250A MCCB can be fitted with a 40A-body trip unit that provides 48 long-time current settings at and below 40A.

For MCCBs above 250A rating and up to 630A, standard electronic trips shall provide as a minimum :

- Long-time protection with 48 current threshold adjustments
- Short-time protection with 8 current threshold adjustments
- Pre-set instantaneous protection
- 150A, 250A, 400A, and 630A protection units.

For MCCBs above 250A rating and up to 630A, there shall also be an optional higher specified trip unit

available that offers, in addition to the above :

- Long-time tripping delay adjustments
- Short-time tripping delay adjustments
- Instantaneous protection with 8 current threshold adjustments
- Instantaneous current threshold tripping delay adjustments
- Indication of fault types
- Optional communications capabilities with Modbus or other industry standard communications
- Optional digital true RMS ammeter display

For example, the 630A MCCB can be fitted with a 150A body trip unit that provides 48 long-time current settings at and below 150A.

3.11.6.2 Discrimination Function

Discrimination shall be provided to comply with AS/NZS IEC 60947-2 and shall be total discrimination. This means that for faults from overloads up to the full prospective short circuit level of the system, only the circuit breaker immediately upstream of the fault shall operate to clear the fault and all other circuit breakers shall remain closed.

The circuit breaker manufacturer may be asked by the Engineer to provide computer-generated calculations in the form of an easily read report that proves discrimination. In the short circuit region, the results shall be based on tests that the manufacturer has carried out that have been incorporated into computer model.

3.11.7 Miniature Circuit Breakers (MCBs)

Miniature circuit breakers (MCBs) shall comply fully with AS/NZS 4898. They shall be removable from the in-service position without removing adjacent circuit breakers and shall be of the trip-free type. The range available shall include breakers with B, C, D and MA tripping curves and shall be available in 6kA, 10kA and 15kA fault ratings. The breaker combinations of MCCB followed by MCB and further downstream MCBs shall provide full discrimination right through the circuit breaker installation.

MCBs shall have a fault rating of not less than the fault level of the distribution system at the point of connection in the switchboard but not less than 6KA. The use of cascading is permitted to provide an increase in a breaker's fault rating.

MCBs shall be capable of being padlocked open using suitable attachments.

Spare MCBs shall be fitted as shown on the DB schedules. Blanking covers shall be fitted to all empty ways.

3.11.8 Cable Details

Cable access shall be from the top and from the bottom of the switchboard. Non-ferrous gland plates shall be fitted to each compartment for cable access.

All cables shall be terminated via bolted compression type terminal lugs. Provide all necessary copper-work to facilitate this. Separation and insulation shall be provided between incoming and outgoing cable terminations.

3.11.9 Contactors

All contactors are to be of best quality with contacts rated for a continuous duty of not less than 16 amps (AC3).

3.11.10 Control Relays

All relays are to be of best quality with contacts rated for a continuous duty sufficient for the application. They shall be encased in sealed enclosures and shall be free from discernible noise when energised.

3.11.11 Control Wiring

All control panel wiring shall be carried out in a neat and systematic manner with cable supported clear of the panels and other surfaces at all points to obtain free circulation of air.
Conductors shall generally have a minimum cross section equivalent to 3/0.77mm (1.5mm^2), 7/0.67mm (2.5mm^2) but single stranded conductors should only be employed for rigid connections which are not subject to movement or vibration during shipment, operation or maintenance.

Wiring to doors shall be anchored at the panel side and sufficient length is to be provided to enable the door to swing fully open without strain on cabling. Full height doors shall be provided with door stays to prevent swinging when open. All panel doors shall be hinged and shall be provided with T'bar locks. At least one T'bar on each compartment shall be key lockable. The same key pattern shall be used for every lock on the whole assembly and a set of keys (minimum of 10) shall be provided with the assembly.

All wires shall be number ferruled using Grafoplast, Critchley type K or Memocab type cable markers or other exactly equivalent system. Do not use industry standard 'C' and 'D' type ferrules.

All outgoing control/controlled field wiring is to be brought out to terminals to facilitate ease of termination. All outgoing control / controlled field wiring is to be brought out to terminals to facilitate ease of termination.

Termination of all wiring at these terminals is to be effected using pre-insulated crimped ferrules or lugs of the correct size to suit cable and terminal capacity.

No wires may be teed or jointed between terminal points.

Bus wiring between panels, cubicles, etc, shall be fully insulated and be completely segregated from the main panel wiring. All wiring of different voltages shall be segregated.

All metallic cases of instruments, control switches, relays, etc, mounted in panels, steel or otherwise, shall be connected by means of green with yellow stripes PVC insulated copper conductors of not less than 2.5mm^2 cross section to the nearest earth bar.

3.11.12 Selector Switches

Rotary selector switches shall comply with the requirements of AS/NZS IEC 60947-5-1 for AC 11 duty.

3.11.13 Terminals – Control Wiring

All terminals shall be mounted in accessible positions. Adjacent terminals shall be adequately spaced to each other and to the incoming cable gland plate. Separate terminations shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.

- Terminal blocks shall not be located less than 200 mm from cable gland plates.
- Provide segregation between LV and ELV terminals.
- Only one conductor shall be terminated in each side of the terminal block.
- Shorting straps shall be used between terminal blocks to bridge identical conductor terminals.
- AC supply connections shall be shielded at the terminal block by means of insulated covers.
- Cubicles shall have space on mounting bars for at least another 20% terminals.

3.11.14 Earthing

Bond all metalwork to main earth bar. Bond all hinged panels with braided flexible copper.

3.11.15 Labels

Panel labels shall be provided to describe the operations of all devices to the Engineer's approval.

Labels shall consist of white lettering engraved on black traffolyte. Lettering shall be 12 mm high for main panel labels and 5 mm high for circuit descriptive labels. All labels shall be fixed with chromium plated or stainless steel screws.

Each cubicle shall be provided with an engraved black and white designation label, and a typed or stencilled chart mounted inside the door giving full particulars of all circuits controlled. Cover chart with 1.6 mm clear Perspex fixed on a rigid frame. The chart shall show all circuit numbers and the location of circuit outlets.

Phases are to be identified by phase colours.

3.11.16 Manufacture

A recognised and approved manufacturer of switchboards, control panels and distribution boards shall be engaged to manufacture all panels.

3.12 Distribution Boards

The Contractor shall submit layout and manufacturing drawings for all distribution boards for review by the Engineer. The Contractor shall receive the Engineer's comments before manufacture commences. All reasonable alterations required by the Engineer shall be included.

3.12.1 General

Distribution boards (DBs) may be included in switchboards to feed local final circuits, in which case the panel construction techniques are to comply with the switchboard requirements.

Particular care is to be taken to ensure that adequate cable termination space is provided.

Circuit description cards are required for each distribution board. These shall be typed and laid out in a way that clearly corresponds to the actual layout of the board. A copy of the circuit card shall be installed in a plastic sleeve mounted on the inside of the cabinet door and additional copies shall be placed in each Maintenance and Operation Manual.

3.12.2 Cabinet Construction

Provide sheet metal, enclosed type, fitted with lockable side hinged doors. They shall be folded 1.6 mm quality baked enamel finish internally and externally. The metalwork on the complete distribution board shall be thoroughly cleaned of all rusting, degreased and primed with zinc chromate. Internal colour is to be white. External colour as specified by the Engineer.

Provide adequate terminal space on neutral and earth bars and adequate wiring space between DBs and ceiling and floor spaces to enable the addition of future sub-circuits up to the full capacity of the board.

All metalwork shall be bonded to the earth bar and starred washers shall be used to provide earth continuity between adjacent steel surfaces.

Boards shall be flush or surface mounted as indicated on the drawings.

No handles shall protrude beyond the front cover/door.

All mechanisms likely to rust shall be cadmium plated or otherwise rust proofed.

3.12.3 Busbars & Connections

Busbars shall be capable of carrying the continuous rated current with a temperature rise not exceeding 20°C above ambient.

Clearances shall be maintained when a current equal to the specified short circuit rating is flowing in the busbars and connections, and shall be capable of withstanding the specified test voltages. Busbars shall be rated at not less than 100 amps each phase.

3.12.4 Circuit Breakers

MCCBs and MCBs shall agree with the requirements above for Switchboards.

3.12.5 Isolators

Every DB shall be provided with effective means of switch-isolation. All live-side terminals of these switches are to be shrouded to prevent accidental contact.

Isolators shall be rated for the continuous load current and for the maximum fault level that may be reached. Isolators shall not be smaller than sizes shown on the drawings or schedules.

3.12.6 Manufacture

A recognised and approved manufacturer of switchboards, control panels and distribution boards shall be engaged to manufacture all panels.

3.13 Battery Charger Panel Construction

The Contractor shall supply a standard charger control panel that has been fully wired and tested at the manufacturer's works. The panel shall be altered as required to agree with this specification.

The control panels shall provide IP 42 or better in accordance with AS1939.

Control panels shall consist of a single panel of rigid sheet metal construction and a minimum steel thickness of 1.2 mm. A hinged and tool-locked or key-locked door shall afford access to the panel and shall have a smooth well-finished surface.

The panel shall be well ventilated through vermin-proof louvers comprising a filter screen attached to a frame and secured to the inside of the panel.

3.13.1 Control Panel Terminals

All terminals shall be mounted in accessible positions. Adjacent terminals shall be adequately spaced to each other and to the incoming cable gland plate. Separate terminations shall be provided on each terminal strip for the cores of incoming and outgoing cables.

All terminals having a circuit voltage of 240 V or higher shall be shielded with an insulated cover marked with a warning notice "Danger Volts".

Only one conductor shall be terminated in each side of the terminal block.

Shorting straps shall be used between terminal blocks to bridge identical conductor terminals.

AC supply connections shall be shielded at the terminal block by means of insulated covers.

Provide segregation between LV and ELV outgoing terminals.

3.13.2 Fuses

Fuses shall be high rupturing capacity type and have minimum capacities equal to that of class AC 80, Q1. They shall have a maximum fusing factor of 1.5 fusing. Fusing factors greater than 1.5 may be used for motor protection only with the approval of the Employer's Representative.

3.13.3 Relays

All relays shall be of best quality with contacts rated for a continuous duty of minimum 10 amps. Auxiliary contacts are to be self-cleaning.