



## CONTRACT

### *EQUIPMENT SUPPLY*

1	ARTICLE I - GENERAL AND DEFINITIONS .....	3
	1.1 GENERAL .....	3
	1.2 CONTRACT .....	3
	1.3 CONTRACT PRICE .....	3
	1.4 DAY .....	4
	1.5 DELAY .....	4
	1.6 DELIVERY AND DELIVERY DATE .....	4
	1.7 NOT USED .....	4
	1.8 EQUIPMENT .....	4
	1.9 FIRST COMMERCIAL USE .....	4
	1.10 FORCE MAJEURE .....	4
	1.11 GUARANTEED PERFORMANCE LEVELS .....	4
	1.12 PAYMENT SCHEDULE .....	4
	1.13 PERFORMANCE TESTS .....	5
	1.14 PERFORMANCE TEST PROTOCOL .....	5
	1.15 PERMITS .....	5
	1.16 SITE .....	5
	1.17 WORK .....	5
2	ARTICLE II - SCOPE OF WORK .....	5
	2.1 RR RESPONSIBILITIES .....	5
	2.2 CUSTOMER RESPONSIBILITIES .....	5
	2.3 PRELIMINARY PLANT LAYOUT .....	6
	2.4 SITE AREA CONDITIONS .....	6
	2.5 AVAILABILITY OF UTILITY CONNECTIONS .....	6
3	ARTICLE III - CONTRACT PRICE AND TERMS OF PAYMENT .....	6
	3.1 CONTRACT PRICE .....	6
	3.2 PAYMENTS AND INVOICING .....	6
	3.3 TAXES .....	7
	3.4 INDEMNIFICATION, SUBCONTRACTORS AND VENDORS .....	7
	3.5 CHANGE ORDERS .....	7
	3.6 MODIFICATION / CANCELLATION .....	7
	3.7 REQUEST BY RR .....	8
	3.8 NOTICE OF DELAY .....	8
	3.9 CHANGE IN WORK AND PAYMENT SCHEDULE .....	8
4	ARTICLE IV - WARRANTY .....	8
	4.1 SCOPE AND TERM .....	8
	4.2 REMEDY .....	9
	4.3 LIMITATION .....	9
5	ARTICLE V - PATENTS .....	10



6	ARTICLE VI - INDEMNITIES .....	10
	6.1 LIMITATION OF LIABILITY .....	11
7	ARTICLE VII - SITE TESTS AND CUSTOMER ACCEPTANCE .....	11
	7.1 SITE TESTS .....	11
	7.2 CUSTOMER'S ACCEPTANCE .....	11
8	ARTICLE VIII - LIQUIDATED DAMAGES FOR DELIVERY, PERFORMANCE .....	11
	8.1 LIQUIDATED DAMAGES .....	11
	8.2 LIQUIDATED DAMAGES – PERFORMANCE LEVELS .....	12
	8.3 LIQUIDATED DAMAGES – DELIVERY DELAY .....	12
	8.4 SET-OFF .....	12
9	ARTICLE IX- TERM OF CONTRACT .....	12
	9.1 TERM .....	12
	9.2 TERMINATION BY CUSTOMER .....	12
	9.3 TERMINATION BY RR .....	13
10	ARTICLE X - CANCELLATION FOR CONVENIENCE .....	13
11	ARTICLE XI - TITLE AND RISK OF LOSS .....	13
12	ARTICLE XII - INSURANCE .....	14
	12.1 CUSTOMER INSURANCE .....	14
	12.2 RR INSURANCE .....	14
13	ARTICLE XIII - PERMITS .....	14
14	ARTICLE XIV - FORCE MAJEURE .....	14
15	ARTICLE XV - WORK BY CUSTOMER .....	14
16	ARTICLE XVI - NOTICE .....	14
17	ARTICLE XVII – OTHER SYSTEMS AND EQUIPMENT .....	15
18	ARTICLE XVIII - NON-DISCLOSURE .....	15
19	ARTICLE XIX - LANGUAGE .....	15
20	ARTICLE XX - USE OF NAME AND RELEASE OF PUBLIC INFORMATION .....	15
21	ARTICLE XXI – DISPUTE RESOLUTION .....	16
22	ARTICLE XXIII - GENERAL PROVISIONS .....	16



This Contract is entered into the \_\_\_\_\_ day of \_\_\_\_\_, 2010, between Energy Parts Solutions, LLC ("Customer"), a Missouri limited liability company, having its principal office at 2031 ProEnergy Blvd., Sedalia, MO 65301, and Rolls-Royce Energy Systems Inc. ("RR"), a Delaware corporation, with its principal office at 105 North Sandusky Street, Mount Vernon, Ohio 43050. RR and Customer may sometimes be referred to individually as "Party" and jointly as "Parties."

**WITNESSETH:**

WHEREAS, Customer desires to contract with RR to provide the equipment and services described in this Contract for a project ("Project") located near Maturin, Monagos , Venezuela and

NOW, THEREFORE, in consideration of the premises and the mutual covenants in this Agreement, and for good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the Parties agree as follows:

## **1 ARTICLE I - GENERAL AND DEFINITIONS**

### **1.1 GENERAL**

This is a contract for the equipment and services described in the Scope of Work attached as Appendix A. The following terms have the meanings specified in this Article I when capitalized and used in the Contract, including any Appendix. The meanings are applicable to both the singular and the plural.

### **1.2 CONTRACT**

"Contract" means this document and any or all of the following Appendices, each of which when attached to this Contract is incorporated into and made a part of the Contract:

- Appendix A Scope of Work
- Appendix B Technical Specifications
- Appendix C Payment Schedule and Delivery Terms
- Appendix D Schedule of Guaranteed Performance Levels and Liquidated Damages
- Appendix E Schedule of Customer Supplied Items
- Appendix F Specimen of Insurance Policy
- Appendix G Cancellation Schedule
- Appendix H Site Performance Test Protocol
- Attachments

### **1.3 CONTRACT PRICE**

"Contract Price" means \$44,000,000, as that amount may be adjusted from time to time by Change Orders under Clause 3.5.

Options (Extras):



- a. Special Tooling as more fully described in Appendix A (Scope of Supply), Section 7.3:  
.....Ex-Works Adder USD\$1,930,560 per Set

## **1.4 DAY**

"Day" or "date" means a calendar day and includes Saturdays, Sundays and holidays, except that, if an obligation to be performed under the Contract falls due on a Saturday, Sunday, national holiday or legal holiday, the obligation will be deemed due on the next business day.

## **1.5 DELAY**

"Delay" means any delay to the Work that is outside of the control of RR, including those delays caused by the Customer or its employees, agents or contractors. To be considered a Delay, the delay must actually impact the schedules, time limits or Work specified under the Contract.

## **1.6 DELIVERY AND DELIVERY DATE**

"Delivery" means delivery of the Equipment in fulfillment of the Delivery Terms stated in the Payment Schedule and Delivery Terms and "Delivery Date" means the date, as may be extended in accordance with these conditions, by which RR undertake to complete Delivery of Equipment, all as stated in Appendix C.

## **1.7 NOT USED.**

## **1.8 EQUIPMENT**

"Equipment" means the items of equipment listed in the Scope of Work (Appendix A) as may be amended from time to time by means of Change Orders ordered pursuant to Article 3.5.

## **1.9 FIRST COMMERCIAL USE**

"First Commercial Use" means the first date power is generated for any purpose other than as required for the purpose of commissioning the Equipment in accordance with written RR procedures and recommendations.

## **1.10 FORCE MAJEURE**

"Force Majeure" means any circumstance or event that is beyond the reasonable control of the Party, such as an act of God or public enemy, explosion, fire, catastrophic storm, earthquake, flood, drought, strikes, lockouts, labor troubles, riots, vandalism, sabotage, embargo, terrorism or terrorist acts or threats, war (whether or not declared and whether or not the United States is a participant), federal, state or municipal law, regulation, order, license, priority, seizure, requisition,

## **1.11 GUARANTEED PERFORMANCE LEVELS**

"Guaranteed Performance Levels" means the level of performance of the Equipment specified in the Schedule of Guaranteed Performance Levels and Liquidated Damages (Appendix D).

## **1.12 PAYMENT SCHEDULE**

"Payment Schedule" means the schedule of payments defined in Appendix C specifying the portion of the Contract Price to be paid upon the occurrence of an event or at an agreed time, and as such schedule may be amended from time to time by Change Orders.



## **1.13 PERFORMANCE TESTS**

"Performance Tests" means the operational tests of the Equipment conducted to verify that the Guaranteed Performance Levels have been achieved. Such Performance Tests shall be completed within the first 200 fired hours of the gas turbine at the Site, and shall be undertaken in accordance with the Performance Test Protocol.

## **1.14 PERFORMANCE TEST PROTOCOL**

"Performance Test Protocol" means the testing procedures, correction curves and methodology for interpretation of results set forth in Appendix H.

## **1.15 PERMITS**

"Permits" means any necessary approval, waiver, consent, variance, license, permit or other similar act on the part of a governmental entity, regulatory agency or other person having authority over the electrical power generation Project's construction and/or operation.

## **1.16 SITE**

The Site for the power generation Project shall be as stated in the Scope of Work (Appendix A).

## **1.17 WORK**

"Work" means the responsibilities of RR as specifically identified in the Scope of Work (Appendix A). Installation of the Equipment, interconnection with the utility, obtaining of Permits and interconnection with Customer's plant or facility are not part of the Work.

# **2 ARTICLE II - SCOPE OF WORK**

## **2.1 RR RESPONSIBILITIES**

RR will perform the Work set forth in this Contract. Subject to the conditions of the Contract, the Work will be commenced and completed in accordance with the dates set forth in the Payment Schedule and Delivery Terms (Appendix C), and will be performed in a good and workmanlike manner with due diligence and without undue delays or interruptions.

RR will provide Customer and the Engineer with the drawings and specifications for Equipment installation. Those drawings and specifications will be provided according to the schedule set forth in the Project Schedule and Delivery Terms (Appendix C). RR is furnishing only the Work specified in this Contract and does not assume any responsibility for the installation and operation of other equipment or material, or the effect thereof on overall operations of which the Equipment is a part. Accordingly, any comments from RR regarding Customer's drawings, plans or construction are advisory only and RR shall not be liable for any such advice.

## **2.2 CUSTOMER RESPONSIBILITIES**

Customer's responsibilities are as set forth in this Contract, including but not limited to furnishing of material and installation of the Equipment (including interconnections), obtaining Permits other than for Warranty Work at Customer's Site if required, providing RR with pertinent information and data, balance of plant equipment specifications and engineering drawings, reasonable access to the Site for on-Site visits and foundations suitable for Equipment installation and the materials, elements and functions described in the Schedule of Customer Supplied Items (Appendix E).



In the event that the Work includes the provision of technical advisers at the Site to give general advice relating to the installation, commissioning and testing of the Work, the Customer shall provide reasonable tool lock-up space and office facilities. Prior to arrival of any RR technical advisers at the Site, Customer must provide the following items at the Site and at Customer's sole cost: all Site labor, temporary and permanent electrical supplies, fuel, water and compressed air for commissioning and testing.

The Equipment is produced to internationally recognized codes and standards. If the location of the delivered Equipment is subject to any special or local codes which are in conflict with these international standards then Customer shall obtain, with the reasonable assistance of RR, waivers from the relevant authorities to permit the use of the Equipment as supplied. Where such waiver cannot be obtained and it is practicable to modify the Equipment to achieve compliance then RR shall be granted the appropriate extension of time and variation in price in order to execute the modifications.

## **2.3 PRELIMINARY PLANT LAYOUT**

Customer is responsible for the design, construction and completion of the facilities in which the Equipment will be located. Customer will comment on drawings and specifications provided by RR within the time periods stated in the Payment Schedule and Delivery Terms (Appendix C).

## **2.4 SITE AREA CONDITIONS**

Customer is responsible for determining the fitness of the Site for the installation and operation of the Equipment. RR may rely upon information obtained from Customer and the Engineer regarding physical characteristics of the Site and has no responsibility or obligation to conduct independent testing or analysis.

## **2.5 AVAILABILITY OF UTILITY CONNECTIONS**

Customer is responsible for ensuring the availability and connection of utilities, including water, fuel and electricity, to the Equipment, as well as the disposal requirements and limitations. RR will provide detailed drawings on the locations of the utility connections to the Equipment.

# **3 ARTICLE III - CONTRACT PRICE AND TERMS OF PAYMENT**

## **3.1 CONTRACT PRICE**

In consideration for the Work, Customer shall pay RR the Contract Price in the manner set out in this Contract.

## **3.2 PAYMENTS AND INVOICING**

RR shall invoice Customer upon occurrence of the events and in the amounts described in the Payment Schedule and Delivery Terms (Appendix C). If Customer disputes an invoice, Customer must submit its objections to the invoice in writing to RR within 14 days after Customer's receipt of the invoice; otherwise the invoice will be deemed accepted (except for invoice related to Change Orders, in which case, the Customer will have 30 days to dispute the invoice). Payments on invoices shall be due 30 days following receipt of the invoice. If Customer fails to make any undisputed payment when due, RR may, in addition to its other rights and remedies, assess and collect interest on the unpaid amount at the rate of 1½% per month. In the event Customer discovers an error in any invoice subsequent to its payment, RR agrees to equitably resolve the issue.



### **3.3 TAXES**

The Contract Price is exclusive of sales, use, excise, personal property, value added, goods and services or similar taxes assessed by or payable to any jurisdiction that may be imposed relative to a sale, use or operation of Equipment. The amount of any such taxes arising from or related to the sale or use of Equipment or the Work will be paid by Customer, or in lieu thereof Customer will provide RR with a tax-exemption certificate acceptable to the taxing authorities.

### **3.4 INDEMNIFICATION, SUBCONTRACTORS AND VENDORS**

RR will indemnify, hold harmless and defend Customer against all liability for mechanics and workmen's liens for Work performed by RR or materials furnished by RR or its subcontractors, including any costs and expenses for attorney's fees incurred by the Customer from any such liens. RR shall within 15 days after written demand, by Customer, make all reasonable efforts to cause the effect of any suits or liens to be removed from Equipment that has become the Customer's property. RR may contest in good faith any such lien filed or suit initiated against Customer after it takes any steps necessary to remove any cloud on title to Customer's property.

### **3.5 CHANGE ORDERS**

Any change to the Work must be ordered in accordance with this Article 3.5. All Change Orders to alter, add to or deduct from the Work must be requested in writing by Customer under the following procedures. If Customer wishes to alter, add to, or deduct from the Work, Customer will prepare a change request and present the change request to RR. Within ten (10) days (or such other period as agreed by the Parties) following receipt of the change request, RR will submit to Customer a written quotation of any adjustment to the Work, Delivery Date(s), Payment Schedule or the Contract Price that would result from the proposed change. If Customer then elects to proceed with the change with the adjustments required by RR, it shall execute a Change Order authorizing modification to the Work and making any revisions to the Delivery date(s), Payment Schedule and Contract Price as shall have been agreed to by RR. RR shall execute a copy of the Change Order and return it to Customer. No Change Order is effective until signed by Customer and RR. Customer will have the right, however, to require that RR commence performance of the Change Order while the Parties are negotiating the changes to the Contract Price and changes to any affected Delivery Date or other performance dates. If the Parties have not agreed on all of the terms to and signed the Change Order within 10 days after Customer's delivery of the Change Order to RR, then RR will have the right suspend performance of the Change Order until all terms are agreed and the Change Order is signed by both Parties. Customer must issue a Change Order in the event of a Delay in accordance with Section 3.8.

### **3.6 MODIFICATION / CANCELLATION**

Without limiting the foregoing, in the event that any change requested by Customer, which, in the reasonable opinion of RR, shall result in a change to the original Contract Price of 10% or more, RR shall have the right to reject the change or to adjust the Payment Schedule, Work schedule and Delivery date(s) by giving written notice thereof to the Customer unless Customer provides reasonable assurance of its ability to pay for the increase to the Contract Price.



### **3.7 REQUEST BY RR**

RR will provide Customer with written notice of any condition or event that RR believes will require modification in or change to the Work, Delivery Date(s), Payment Schedule or Contract Price. The notice will describe the condition or event in detail. As soon as practicable following delivery of the notice, RR will specify the adjustment to the Work, Delivery date(s) Payment Schedule and Contract Price. Following receipt of that notice, Customer will, in good faith and using reasonable discretion, determine whether any changes to the Work, Delivery Dates, Payment Schedule or Contract Price will be effected; provided, however, that RR is entitled to a Change Order necessitated by any Delay.

### **3.8 NOTICE OF DELAY**

Within three (3) Days after a Party becomes aware of a Delay, that Party must give prompt written notice of the Delay to the other Party, including all details concerning the Delay in the possession or knowledge of the notifying Party. Promptly after RR determines the details of the Delay, RR will notify Customer in writing of the anticipated effect on the Work, the Delivery Date, or Contract Price. Customer will, within 10 days following receipt of the notice, or following any other period agreed upon by the Parties, issue a Change Order extending the time for performance of the Work for the period of the time by which RR has been delayed and/or adjusting the Contract Price.

### **3.9 CHANGE IN WORK AND PAYMENT SCHEDULE**

The time for performance of all RR's obligations, including, but not limited to, the obligation to pay liquidated damages, may be extended by Change Order.

## **4 ARTICLE IV - WARRANTY**

### **4.1 SCOPE AND TERM**

RR warrants to Customer that the Work shall be performed in accordance with good engineering practices for electrical power generation projects, and that, when complete, and subject to proper installation and interconnection by Customer in accordance with RR's installation and commissioning manuals and procedures, the Equipment will be compliant with the terms set forth in this Contract. RR further warrants that the Equipment will be new, free from defects in materials and workmanship. Unless otherwise stated in Appendix A, these warranties shall be in effect for the period commencing upon Delivery and expiring twelve (12) months following the later of First Commercial Use or 200 fired hours or eighteen (18) months from the date of Delivery (or, in the event Customer desires to defer or postpone Delivery for any reason other than Force Majeure, notification by RR of readiness to Deliver), whichever period expires soonest.





## 4.2 REMEDY

If the Equipment or any of its components prove to be defective pursuant to Clause 4.1 above, and the Equipment is returned to RR's factory within the warranty period or within thirty (30) Days thereafter, with commercially reasonable transportation charges at the expense of RR, and the Equipment is found to be defective, it will be repaired or replaced, at the sole discretion of RR, free of charge to the Customer. RR will return the repaired or replaced Equipment to Customer using the commercially reasonable shipping means. Customer must pay, in advance of shipping, any additional charges for airfreight or other special handling. If Customer desires repair to be performed at its Site, all expenses incurred by RR above and beyond those that would have been incurred if the repair had been performed at RR's plant, are Customer's responsibility. If RR fails to respond to a Customer claim of defect within 3 days after Customer notifies RR of the claim, Customer may remedy the defect and charge RR for the reasonable cost of the necessary repairs, which repairs must be performed in a commercially reasonable manner. This Clause 4.2 constitutes Customer's sole and exclusive remedy for breach of the foregoing warranties of RR. Repairs performed in a manner inconsistent with RR written instructions, manuals and other commonly referenced state and federal codes and standards, or in a manner that is otherwise negligent may result, at the option of RR, in the termination of the warranty on the repaired Equipment item in question and any other parts of the Equipment affected as a consequence of Customer's own modifications or repairs.

Replacement and repair parts will carry the remainder of the original warranty period as set forth in Clause 4.1, or shall be warranted for one (1) year from the date of delivery, whichever is greater. Notwithstanding the foregoing, the warranty period for any and all parts of the Equipment shall be limited to a maximum period of thirty (30) months following the original Delivery Date for such part of the Equipment.

## 4.3 LIMITATION

The warranties set forth in this Contract apply only if the Equipment is used, operated, stored, maintained and repaired in accordance with good and diligent storage, operating and maintenance procedures and the written recommendations of RR and the manufacturer of the Equipment as set forth in service and support manuals, bulletins or other written instructions furnished by RR or the manufacturer to Customer.

Guaranteed Performance Levels apply only when the Equipment is new and in clean condition. The equipment descriptions provided in the proposal are for information only and are not to be considered part of the warranty.

RR has no responsibility or liability in relation to the use, operation and maintenance of ancillary equipment and systems provided by the Customer or for the performance of the Customer's employees. Accordingly, except as explicitly set forth herein, RR makes no representations or warranties of any kind relating to the Customer's equipment, systems, or any components, parts or modules thereof, or the operation or performance of any of the foregoing alone or in conjunction with any equipment or services provided by Customer.

EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH IN THIS CONTRACT, RR DISCLAIMS ALL WARRANTIES OF ANY KIND INCLUDING WITHOUT LIMITATION, THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.



## **5 ARTICLE V - PATENTS**

If Customer receives a claim that the Equipment or part thereof supplied by RR, when used in the manner contemplated herein, infringes a patent, Customer will notify RR promptly in writing and give RR all available information, assistance and exclusive authority to evaluate, defend and settle the claim. RR will then indemnify, defend and hold Customer harmless, at its own expense and option (1) settle the claim, or (2) procure for Customer the right to use the Equipment or (3) replace or modify the Equipment to avoid infringement, or (4) defend against the claim. If any court of competent jurisdiction holds the Equipment or the use thereof to constitute a patent infringement, RR, will pay any costs and damages finally awarded on account of the infringement, and if the use of the Equipment is enjoined, RR will take at its option either or both of the actions under (2), or (3) above.

Customer must notify RR in writing promptly after Customer receives notice of any such claims of infringement of patents occurring in connection with the performance of the Work. In turn, RR will promptly notify Customer in writing of any claims that RR receives alleging infringement of patents or other proprietary rights that may affect RR's performance of the Work.

The rights and obligations of the Parties with respect to patents are solely and exclusively as stated in this Contract. The obligations of RR set forth in this Article 5 do not apply to the extent the Equipment, products or systems is/are manufactured by RR to Customer's design or specification, or under Customer's direction, or for a specific, custom application of Customer.

THE PATENT WARRANTY OBLIGATIONS RECITED ABOVE ARE WRITTEN IN LIEU OF ALL OTHER PATENT WARRANTIES WHATSOEVER, WHETHER ORAL, WRITTEN, EXPRESS OR IMPLIED.

## **6 ARTICLE VI - INDEMNITIES**

Subject to the limitations set forth in this Contract, RR agrees to indemnify, hold harmless, release, and defend Customer its agents, employees, directors and officers, from and against any and all cost, loss, liability or expense including without limitation, attorney fees, arising out of or relating to third party claims for injuries or death to persons or damage to property to the extent caused by the negligence or intentional wrongful acts of RR, its subcontractors, employees or agents. Customer agrees to promptly notify RR of any such claims and assist RR in the defense of the claim. Any claim brought by Customer for indemnification under this Contract must be brought within 4 years after the date of Delivery.

Subject to the limitations set forth in this Contract, Customer agrees to indemnify, hold harmless, release, and defend RR, its agents, employees, directors and officers, from and against any and all cost, loss, liability or expense including without limitation, attorney fees, arising out of or relating to third party claims for injuries or death to persons or damage to property to the extent caused by the negligence or intentional wrongful acts of Customer, its subcontractors, employees or agents, or any party to whom Customer conveys or sells the Equipment, unless Customer has assigned this Contract (as provided in Section 22) with the Equipment. RR agrees to promptly notify Customer of any such claims and assist Customer in the defense of the claim. Any claim brought by RR for indemnification under this Contract must be brought within 4 years after the date of Delivery.



## **6.1 LIMITATION OF LIABILITY**

The total liability of RR (including its subcontractors) in the aggregate under this Contract, whether in contract, tort (including negligence of any degree), infringement or otherwise, arising out of, connected with, or resulting from the manufacture, sale, delivery, resale, repair, replacement or use of the Equipment or the performance of the Work or any other service or recommendations shall not exceed the Contract Price. Notwithstanding the foregoing, if a claim is based on RR's indemnification obligation, the total liability for the indemnity claim shall be limited to the Contract Price (less any amounts previously paid for any other claims) plus any insurance proceeds recovered under any applicable RR policies.

The total liability of Customer in the aggregate under this Contract, whether in contract, tort (including negligence of any degree), infringement or otherwise, arising out of, connected with Customer's obligations under this Contract shall not exceed the Contract Price. Notwithstanding the foregoing, if a claim is based on Customer's indemnification obligation, the total liability for the indemnity claim shall be limited to the Contract Price (less any amounts previously paid for any other claims) plus any insurance proceeds recovered under any applicable Customer insurance policies.

IN NO EVENT, WHETHER AS A RESULT OF BREACH OF CONTRACT, ALLEGED NEGLIGENCE, OR OTHERWISE, SHALL RR BE LIABLE FOR INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES SUCH AS, BUT NOT LIMITED TO, LOSS OF PROFITS OR REVENUE, LOSS OF USE OF PRODUCTS SUPPLIED BY RR, COST OF CAPITAL, COST OF PURCHASED REPLACEMENT EQUIPMENT, DOCK CHARGES, BUSINESS INTERRUPTION, COST OF MAINTAINING CREWS, INCLUDING CREWS' WAGES, OR OTHER SIMILAR ITEMS OF DAMAGE.

## **7 ARTICLE VII - SITE TESTS AND CUSTOMER ACCEPTANCE**

### **7.1 SITE TESTS**

Site Performance Tests, when required as part of the Contract, will be conducted according to the RR Performance Test Protocol to determine compliance with Guaranteed Performance Levels. Guaranteed Performance Levels apply only to Equipment in new and clean condition prior to the gas turbine having completed 200 fired hours running at the Site.

### **7.2 CUSTOMER'S ACCEPTANCE**

The Equipment will be deemed accepted and the Work completed upon completion of installation and commissioning. In any event, the Equipment will be deemed accepted and the Work completed not later than First Commercial Use or 200 fired hours or six (6) months following initial placement by Customer of the Equipment into storage, whichever is later. Any and all uncompleted performance, acceptance or other tests shall then be deemed to have been successfully completed. Thereafter, any claim for defect or malfunction must be made under the warranty set forth in Article IV.

## **8 ARTICLE VIII - LIQUIDATED DAMAGES FOR DELIVERY, PERFORMANCE**

### **8.1 LIQUIDATED DAMAGES**

In the event that RR fails to Deliver the Equipment by the Delivery Date, or if the Equipment fails to demonstrate the Guaranteed Performance Levels, RR shall pay to the Customer liquidated damages as set out in this Article VIII.



## **8.2 LIQUIDATED DAMAGES – PERFORMANCE LEVELS**

If Performance Tests demonstrate that the Equipment does not achieve the Guaranteed Performance Levels, RR will first be given adequate opportunity to modify or adjust the Equipment to improve the performance, prior to the imposition of liquidated damages. If within sixty (60) days from the Performance Tests, RR has not rectified the deficiency, RR will pay to Customer (subject to Article VI) liquidated damages, not as a penalty, in an amount as calculated per the Schedule of Guaranteed Performance Levels and Liquidated Damages (Appendix D). The liquidated damages will be the sole remedy of Customer against RR and the sole liability of RR to Customer for failure to meet Guaranteed Performance Levels unless said performance for any guaranteed criteria is deficient by more than ten (10) percent.

## **8.3 LIQUIDATED DAMAGES – DELIVERY DELAY**

If RR does not deliver the Equipment by the Delivery Date, RR agrees to pay liquidated damages provided that the failure is not caused by Delays Force Majeure or as may be specified in a Change Order. Delays, Force Majeure and as may be specified in a Change Order entitle RR to extend the Delivery Date for a period commensurate with the duration and nature of the Delay, Force Majeure or as may be specified in a Change Order. Any liquidated damages that become payable under this clause, will be calculated in accordance with the Schedule of Guaranteed Performance Levels and Liquidated Damages (Appendix D). If Delivery is delayed more than 180 days beyond the Delivery Date (as extended), Customer may reject the Equipment affected and RR will refund any previously paid portions of the Contract Price that relate to the rejected Equipment. In all other cases, the liquidated damages payable are the sole remedy of Customer against RR and the sole liability of RR to Customer for failure to meet the Delivery Date.

## **8.4 SET-OFF**

Neither Customer nor any affiliated company or assignee of Customer has the right to set off against any amounts that may become payable to RR under this Contract, any amounts that RR may allegedly owe or in fact owes Customer or any affiliated company or assignee on any warranty or other claim that Customer may have arising under this Contract. .

# **9 ARTICLE IX- TERM OF CONTRACT**

## **9.1 TERM**

The term of the Contract will be from the date first set forth above until complete performance of the Work; provided, however, that all warranties and indemnities contained in this Contract, including any third party warranties assigned to Customer, will survive the term of the Contract in accordance with their specific terms.

## **9.2 TERMINATION BY CUSTOMER**

Customer may terminate the Contract on 7 days' prior written notice if RR: (i) is adjudicated bankrupt; (ii) makes a general assignment for the benefit of its creditors; (iii) has a receiver appointed on account of insolvency; or (iv) takes equivalent or similar actions to protect itself from claims of creditors.



Customer may terminate the Contract on thirty (30) days' prior written notice if RR materially defaults in the performance of any material obligation under the Contract. Failure by the Contractor to achieve Delivery by the Delivery Date and failure to achieve the Guaranteed Levels of Performance are addressed by liquidated damages and are not material defaults. RR will have thirty (30) days from receipt of written notice of termination to cure any default, or if the default cannot reasonably be cured within the thirty (30) day period, with Customer's agreement, which shall not be unreasonably withheld, to commence and diligently prosecute the cure. If the default is cured within the cure period as the same may be extended by agreement of the Parties, the Contract will be deemed to have continued in full force and effect without interruption.

### **9.3 TERMINATION BY RR**

RR may suspend the Work or terminate the Contract on 7 days' prior written notice if Customer (i) is adjudicated bankrupt; (ii) makes a general assignment for the benefit of its creditors; (iii) has a receiver appointed on account of insolvency; or (iv) takes equivalent or similar actions to protect itself from claims of creditors.

RR may suspend the Work or terminate the Contract if Customer materially defaults in the performance of any of its material obligations under the Contract, by giving written notice of suspension or termination to Customer, and RR will be entitled to the cancellation fee determined in accordance with Schedule of Cancellation Fees (Appendix G). Customer will have thirty (30) days from the receipt of the written notice to cure any non-monetary default and 10 days to cure any default in payment to RR. If the default is cured within the applicable cure period (as it may be extended by agreement of the Parties), the Contract will be deemed to have continued in full force and effect. If RR gives notice of termination or suspension, the time for performance will be extended for a reasonable period to allow for the cure and a period of re-staging for the Work. RR may convert the suspension into a termination on 7 days' written notice to Customer if Customer fails to cure such default.

## **10 ARTICLE X - CANCELLATION FOR CONVENIENCE**

If Customer chooses to cancel the Contract or any portion of it for any reason other than the default of RR, Customer shall give written notice to RR and shall pay a cancellation fee to RR within thirty (30) days of the date of issue of the notice. RR shall cease all Work upon receipt of such notice. The cancellation fee shall be determined in accordance with Schedule of Cancellation Fees (Appendix G) of the Contract. Title to all Work performed up to the date of cancellation, whether completed or not, shall be retained by RR.

## **11 ARTICLE XI - TITLE AND RISK OF LOSS**

Delivery terms are as stated in Appendix C and in accordance with Incoterms 2000. Risk of loss for Equipment shall transfer to Customer in accordance with the Delivery terms.

Title shall transfer from RR to Customer either upon Delivery or upon receipt by RR of the full Contract Price, whichever shall occur the later.



## **12 ARTICLE XII - INSURANCE**

### **12.1 CUSTOMER INSURANCE**

Without limiting the RR obligations, liabilities and responsibilities under the Contract, Customer shall, in the joint names of Customer and RR, insure the Equipment and keep each part of it insured for its full replacement value against all loss or damage from whatever cause during the course of Site erection and commissioning activities whilst RR has an obligation to provide advisory services. RR shall remain an additional insured on such insurance until 30 days after First Commercial Use and the insurance shall extend to cover RR in the event that RR is required to return to the Site during the Warranty period.

### **12.2 RR INSURANCE**

RR will effect and maintain at its own expense, insurance policies with insurers and under terms as shown in Specimen Insurance Policy (Appendix F).

## **13 ARTICLE XIII - PERMITS**

If a Permit or regulatory approval is required to install or operate the Equipment or is required for the approval of the plans or specifications for the Equipment, Customer assumes responsibility and expense of securing the requisite Permits or approval and RR will provide all reasonable assistance in connection therewith.

## **14 ARTICLE XIV - FORCE MAJEURE**

Notwithstanding any other provision in this Contract, if either Customer or RR fails to perform or is delayed in performing any of its obligations under the Contract within the time specified in the Contract for such performance, and if caused by Force Majeure, then the failure or delay will not constitute a breach of the Contract, nor subject the Party so failing to any liability to the other, and the time of performance will be extended for the duration of the Force Majeure. The claiming Party must notify the other Party of the existence of the condition and its expected duration in writing within three (3) days of becoming aware of the Force Majeure event and must exert reasonable efforts to eliminate or terminate the cause of the failure or delay.

## **15 ARTICLE XV - WORK BY CUSTOMER**

Since the Work is one part of the Project being undertaken by Customer, RR's performance under this Contract may be dependent upon work on other parts of the Project by Customer, on and about the Project Site during the time RR is performing the Work. RR will be entitled to extend the schedule for performance as a result of Delays caused solely by the work on the Project or on and about the Project Site performed or to be performed by Customer provided that RR shall be obligated to do everything commercially reasonable to avoid and minimize the effects of such Delay with respect to its Work. In addition, RR is entitled to reimbursement of any additional out of pocket costs incurred as a result of Delays caused by the Customer. RR will promptly notify Customer in writing within three (3) Days of any Delays resulting from work by Customer.

## **16 ARTICLE XVI - NOTICE**

Any notice, demand, offer or other written instrument required or permitted to be given under the Contract ("notice") must be in writing signed by the Party giving the notice and must be hand delivered or sent by cable, facsimile transmission (with confirmation copy by air mail), certified mail, postage prepaid or overnight courier, to the other Party at its address set forth below:



If delivered to RR:                      Rolls-Royce Energy Systems Inc.  
   105 North Sandusky Street,  
   Mount Vernon  
   Ohio 43050

If delivered to Customer:              Energy Parts Solutions, LLC  
   2031 ProEnergy Blvd.  
   Sedalia, Missouri 65301  
   Attention: Jeff Canon

Each Party may change the place to which notices are to be sent or delivered. The change will be effected by notice to the other Party under this Article XVI. Any notices or other communications given by either Party will be deemed to have been duly given, if by facsimile transmission, 24 hours after sending, and if by mail, upon deposit with the United States Postal Service, proper postage prepaid, return receipt requested.

## **17                      ARTICLE XVII – OTHER SYSTEMS AND EQUIPMENT**

RR is furnishing only the Equipment specified in this Contract and does not assume any responsibility for other equipment, systems or material not supplied by RR, nor the effect of the Equipment or Work on the overall operation of the system of which the Equipment is a part.

## **18                      ARTICLE XVIII - NON-DISCLOSURE**

Customer agrees to hold in confidence any information, specifications, know-how, reports, data and drawings that it acquires directly or indirectly from RR and agrees not to use or disclose the same to any third party without the prior written approval of RR in each instance except in the use, operation, installation and maintenance of the Equipment.

## **19                      ARTICLE XIX - LANGUAGE**

All documents relating to this Contract and the related Project, including without limitation, all contracts, agreements, schedules, drawings, specifications and communications will be in the English language.

## **20                      ARTICLE XX - USE OF NAME AND RELEASE OF PUBLIC INFORMATION**

No public release of information (including, without limitation, photographs, films, announcements, and denials or confirmations) with respect to this Contract or its subject matter, or any order or phase of any program hereunder, may be made by either RR or Customer without the prior written approval of the other Party which approval shall not be unreasonably withheld. Customer may make no use of or reference to the "Rolls-Royce" name or any Rolls-Royce company name or trademark without the prior written approval of RR, except in the use, operation, installation and maintenance of the Equipment.



## 21

### **ARTICLE XXI – DISPUTE RESOLUTION**

If at any time any dispute or difference arises between Customer and RR pursuant to the Contract either party shall as soon as is reasonably practicable give notice to the other of the existence of such dispute or difference specifying its nature and the point at issue. The Parties shall make reasonable efforts to resolve their differences including if applicable, referral to the senior management of each Party or to non-binding mediation by a third party.

If the dispute or difference remains unresolved after two weeks following delivery of the notice or following such other period as may be agreed, either party may by notice to the other, elect to refer the matter to arbitration. Any arbitration will be administered by the American Arbitration Association under its Commercial Arbitration Rules, will be final and binding, and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction thereof. Any such proceeding will take place in Houston, Texas.

Performance of the obligations under the Contract shall continue during arbitration proceedings unless agreed otherwise by the Parties. No undisputed payment due or payable by Customer shall be withheld on account of a pending reference to arbitration.

## 22

### **ARTICLE XXIII - GENERAL PROVISIONS**

The definition of terms used, interpretation of this Contract and rights of Parties will be construed under the laws of the State of Texas, excluding its conflict of law provisions. Customer and RR consent to jurisdiction in Texas and agree, subject to Article 21, that any action or proceeding arising out of this Contract or the performance of any Party shall be brought in any court of competent jurisdiction in Houston, Texas. The prevailing Party, whether in court or through arbitration under Article 21, will indemnify and reimburse the other Party for its reasonable attorneys' fees and expenses and costs of court or the arbitration.

No waiver, amendment or modification of this Contract will be binding upon either Party unless made in writing and signed by a duly authorized representative of such Party. The Parties have each participated in the drafting and preparation of this Contract. No rules of construction based on authorship apply.

This Contract sets forth the full and complete agreement of the Parties. The Contract supersedes any and all proposals, negotiations and representations of the Parties made or had prior to the execution hereof relative to the subject matter of the Contract. Headings are for convenience only and are not to affect the interpretation of any provision in this Contract.

The Parties expressly agree that the United Nations Convention on Contracts for the International Sale of Goods does not apply to this Contract or any transactions hereunder.

This Contract is binding upon and inures to the benefit of the Parties, their respective successors and assigns.

Neither Party will have the right to assign this Contract without the prior written consent of the other Party. RR will have the right, however, to subcontract those portions of the Contract that RR subcontracts in the ordinary course of RR's operations.

In Witness whereof, the Parties have executed this Contract as of the date first above written.

Rolls-Royce Energy Systems Inc.





# Rolls-Royce

**CONTRACT**  
EQUIPMENT SUPPLY

By \_\_\_\_\_

Title \_\_\_\_\_

Energy Parts Solutions, LLC

By \_\_\_\_\_

Title \_\_\_\_\_



**PROJECT No.** \_\_\_\_\_

**APPENDIX A**  
**EQUIPMENT SUPPLY CONTRACT**  
**SCOPE OF WORK**

- Project Site

The Site is located at Venezuela.

- Scope of Work

**Base Scope of Supply**

- The base scope of supply for Two (2) Trent 60 Dual Fuel WLE Power Generation Packages, designed in accordance with the specifications outlined in this contract

**1. Gas Turbine Model**

- Rolls-Royce Industrial Trent 60 Gas Turbine with Natural Gas Wet Low Emissions (WLE) combustors
- Single annular combustion system with twenty four natural gas fuel injectors with on-engine mounted fuel and water (for NOx control) manifold
- Gas Turbine ignition system consisting of two on-engine igniters and off-engine mounted exciter unit
- Simplex shaft driven pump including 8 supply and 2 scavenge pump sections
- Electric Start Motor with Integral Synthetic Oil Cooling and Free Issued VFD for installation by others in a Controlled Environment
- On engine accelerometers for vibration monitoring

**2. Gas Turbine Driver Package**

**2.1 Baseplate**

- Fabricated continuous grout multi-point mount baseplate with 30 inches (762 mm) beam height. Baseplate houses radial intake plenum, Trent 60 Gas Turbine, fuel system, gas turbine synthetic oil system, exhaust volute, and gas turbine enclosure

**2.2 Gas Turbine Enclosure**

- Fabricated weatherproof enclosure to give an overall average package acoustics performance of 85 db(A) @ 1m dB(A) avg. from the module at an elevation of 1.5 m including:
- Suitable for site ambient condition to 0 to +40 deg C
- Ventilation inlet / outlet ducting constructed of carbon steel interior and exterior painted to Rolls-Royce paint specification.
- Silencer constructed of stainless steel.
- Maintenance access rail system facilitating engine removal and installation
- All internal Gas Turbine package lighting (main and emergency), tubing, piping and wiring within flexible conduit
- Ventilation system using filtered air from the inlet air filter house
- Negative pressure ventilation system using three (3) x 50% ventilation fans
- Anti-condensation motor and Enclosure Space heaters are provided within the Gas Turbine enclosure to preventing condensation
- Connection points for the water wash system are externally located on the outside of the gas turbine module



## 2.3 Fire System

- Pneumatically controlled fire dampers for the gas turbine ventilation exhaust and intake
- Warning lamps (beacons and alarm horns), personnel lock-outs for maintenance, interlocks and high temperature wiring within flexible conduits
- Fire and gas detectors including:
  - Multi-spectrum infrared gas turbine enclosure flame detectors - Quantity - Four (4)
  - Rate of Rise/High Temperature type gas turbine enclosure heat detector - Quantity - Two (2)
  - Point Infrared extended probe ventilation outlet gas detectors - Quantity - Two (2)
- Detector Electronics (brand) Eagle Quantum Premier fire and gas controller
- Fire protection system including:
  - Two-shot CO2 to NFPA 12 and NFPA 72 extinguishing system, including storage container located on a carbon steel skid, painted to Rolls-Royce paint specification, for 100% discharge to extinguish the fire and an additional 100% discharge to suppress re-ignition
- Manifold and pipework to nozzles within the gas turbine enclosure

## 2.4 Pipe, Wiring in Flexible Conduit, and Tube

- All piping is 316 Stainless Steel
- All on skid flexible conduit with galvanized steel inner core per GER 0018.
- All wiring will terminate in junction boxes
- All tubing is 316 Stainless Steel

## 2.5 Coupling

- Dry Flexible element with a service factor of 1.2

## 2.6 Combustion Air System

### 2.6.1 Air filter

- Pulse Clean combustion and ventilation air filter
- Pre filtration water droplet separator
- Structural supports manufactured from galvanized carbon steel
- Pulsed cleaning control system fitted on the filter unit. The air required for the pulse cleaning of the Air Filter will be supplied by others
- Air filter mounted from grade (foundations by others) with the support structure and access ladders / elevated walkways with guardrails supplied

### 2.6.2 Combustion Air Ducting and Silencer

- Combustion air ducting made of Carbon Steel is painted internally and externally to Rolls-Royce paint specification
- Silencer internally lined located in combustion air ducting made of stainless steel

### 2.6.3 Inlet Plenum

- Located in the Gas Turbine enclosure
- Intake plenum constructed of carbon steel painted to Rolls-Royce specifications
- Radial air intake scroll with integral compressor water wash manifold and nozzles

### 2.6.4 Exhaust

- The combustion exhaust system including:
  - Exhaust transition volute
  - Exhaust system, including expansion joint, silencer, structural support and stack by others

## 2.7 Synthetic Oil System

### 2.7.1 Synthetic Oil Reservoir



- 316 stainless steel synthetic oil reservoir
- Thermostatically controlled electric heater
- Oil mist separator

## 2.7.2 Synthetic Lubrication Oil System

- Oil filter
- Stainless Steel Pipework, fittings, and associated valves / instrumentation
- Plate Type Water-Oil (1x100%)

## 2.7.3 Synthetic Control Oil System

- Gas Turbine hydraulic control oil system including:
- Two (2) x 100% AC motor driven displacement pumps
- One (1) x 100% bladder type accumulators
- Oil filter
- Stainless Steel Pipework, fittings, and associated valves / instrumentation

## 2.7.4 Synthetic Starting Motor Cooling Oil System

- Used to cool the Electric Starting Motor

## 2.8 Start System

- Gas turbine mounted electric variable frequency drive start system including:
- Electric off-skid air cooled power electronics and controller unit for variable frequency drive (2 bay panel)

## 2.9 Fuel System

### 2.9.1 Gas Fuel Metering System

- Fuel gas system, located within the gas turbine enclosure, designed to operate from a suitable customer supplied source of fuel, including:
- High speed shutoff / isolation valves
- Digitally controlled fuel modulating valve
- High speed fuel vent valve
- Gas fuel manifolds
- Flanged fuel gas connection at skid edge
- Stainless Steel Pipe work and fittings, associated valves and instrumentation

### 2.9.2 Liquid Fuel Metering System

- Liquid fuel metering system, located within the gas turbine enclosure, designed to operate from a suitable customer supplied source of fuel, including
- High speed shutoff / isolation valves
- The liquid fuel connection at skid edge will be flanged
- Stainless Steel Pipe work and fittings, associated valves and instrumentation

### 2.9.3 Purge Air System

- Purge Air System, located within the gas turbine enclosure, designed to operate from a suitable customer supplied source of cooling water, including
- Shell and Tube Type Water-Air.
- The cooling water connection at skid edge will be flanged
- Stainless Steel Pipe work and fittings, associated valves and instrumentation



## 2.9.4 Wet Low Emissions (WLE) Water Injection skid

- Water injection system, mounted on a separate skid, located adjacent to the gas turbine package, designed to operate from a suitable customer supplied source of demineralized water, including:
- Variable Frequency electric motor driven pump - Quantity - 3 x 33%
- Filter
- On skid Stainless Steel Pipe work and fittings, associated filter, valves, and instrumentation

## 2.9.5 Liquid Fuel injection skid

- Liquid HP injection system, mounted on a separate skid, located adjacent to the gas turbine package, designed to operate from a suitable customer supplied source of fuel, including:
- AC electric motor driven pump - Quantity – One (1) x 100% liquid fuel pump.
- AC electric motor driven pump - Quantity – One (1) x 100% variable frequency drive water flush fuel pump.
- Liquid fuel filter.
- On skid Stainless Steel Pipe work and fittings, associated filter, valves, and instrumentation

## 2.10 Offline Water Wash

- Mobile offline compressor cleaning system supplied 1 per Site including:
- Connection points for the water wash system are located on the wash cart
- Water wash, polyethylene solution tank with pneumatic pump

## 3. Driven Equipment

### 3.1 AC Generator Package

#### 3.1.1 Two (2) Pole Open Air Cooled AC Synchronous Generator

- AC generator rating:
  - 13.8 kV / 60Hz including the following features
  - IP54 degree of protection
  - Class F Insulation with a Class B operating temperature rise
- Stator and Bearing Metal RTDs
- Exciter air stream RTDs
- Automatic Voltage Regulator (AVR)
- Sole plates provided for Plinth Mounting by others
- Line side and Neutral Cubicles, including Current and Potential Transformers and space heaters
- Space heaters are provided within the AC Generator stator housing
- Coupling with guard for personnel protection

#### 3.1.2 Mineral Oil System

- Mineral lube oil reservoir with thermostatically controlled electric heater
- One (1) x 100% shaft (AC generator) driven pump
- One (1) x 100% AC motor driven pump
- One (1) x 100% AC motor driven jacking pump
- One (1) x 100% DC motor driven backup pump
- Oil filter
- On skid Pipework, fittings, and associated valves / instrumentation
- Plate Type Water-Oil cooler (1x100%)
- Interconnecting piping by others

#### 3.1.3 Base

- AC Generator is designed to be concrete plinth mounted

#### 3.1.4 Enclosure



- The AC Generator is suitable for outdoor installation without a separate enclosure;
- AC Generator is provided with Acoustic Treatment for an overall average package acoustics performance of 85 dB(A) average @ 1m (3 ft) from the package at an elevation of 1.5 m (5 ft) from grade.

#### **4. Controls (Free issued for mounting in control room)**

- Gas Turbine unit control panel (UCP) (4-bay panel) including:
  - Gas Turbine suitable for local / remote protection, control, monitoring, start, stop, sequencing and indication
  - Gas Turbine fuel scheduling control functions
  - Gas Turbine Oil flow scheduling and protection function for gas generator oil console
  - Unit Vibration Monitoring integrated into the Gas Turbine Safety Control System.
  - Data from both systems is available through the OPC interface.
  - Unit Control Panel, free issued, which must be located in environmentally controlled area, by others within 100 meters of Gas Turbine Package
  - Integral HMIs (Human Machine Interfaces)
- AC Generator Control and Protection Panel (GCCP) (2 bay panel)
- One (1) Factory Acceptance Test (FAT) per Contract (first unit only)
- One (1) Maintenance Laptop
- One (1) HMIs (Human Machine Interface) free issued

#### **5. Testing**

- Gas turbine - Manufacturers Internal Standard Full load factory test including performance and emission verification (not witnessed)
- AC generator -Manufacturers Internal Standard Factory Acceptance Test (not witnessed)
- Control Panel - Manufacturers Internal Standard Factory Acceptance Test (not witnessed)
- Gas turbine package standard factory testing and loop checks (not witnessed)
- AC generator package standard factory testing and loop checks (not witnessed)
- Rolls-Royce Witness of site test of gas turbine generator package.

#### **6. Engineering**

##### **6.1 Documentation**

- Documentation supplied according to the Supplier Documentation Requirements List (SDRL) included in Appendix C.
- Three sets of Operating Manuals (CD format) in English.
- Three sets of Maintenance Manuals (CD format) in English.
- All equipment tags and language used on the equipment will be in the English Language.

#### **7. Installation and Commissioning Services**

##### **7.1 Training**

- Turbo generator package training is provided at a Rolls-Royce Training Center location.

##### **7.2 Commissioning spare parts**

- Commissioning Spares are included

##### **7.3 Installation and Commissioning Special Tooling**

- The following special tooling will be supplied for a refundable deposit above the equipment unit purchase price herein on a temporary basis during the installation period only and returned to RR. Once this equipment has been returned to RR complete and undamaged a refund shall be given to the Customer. In lieu of the refundable deposit, Customer can procure the below special tooling for an



additional price adder.

- One set of Coupling Installation Tooling
- One GT Installation Kit
- One Starter and Clutch Change out Kit
- One Gas turbine transportation stand suitable for air freight
- One set of Lifting beams for gas turbine transportation stand and gas turbine
- One Baseplate Field Alignment Jig
- One Gas turbine transportation stand suitable for air freight
- One set of Lifting beams for gas turbine transportation stand and gas turbine

## 8. Preparation and Shipping

- Preparation for inland shipping

## 9. Package Codes and Standards

- The Package is based on design, manufacture and delivery of the Equipment in accordance with Rolls-Royce's standard design criteria listed below, manufacturing processes and procedures, and quality assurance program, and portions of industry specifications, codes and standards in effect as of the date hereof which RR has deemed applicable to the Equipment and Services.
- If the location of the delivered Plant is subject to any special or local codes, not explicitly stated in the contract, which are in conflict with these international standards then Customer shall obtain, with the reasonable assistance of the Rolls-Royce waivers from the relevant authorities to permit the use of the plant as supplied. Where such waiver cannot be obtained and it is practicable to modify the plant to achieve compliance then the Customer shall be granted the appropriate extension of time and variation in price in order to execute the modifications.
- The Rolls-Royce Package offered has been designed to conform to the internationally recognized codes and standards listed below:
  - 98/37/EC The Supply of Machinery (Safety) Regulations
  - 97/23/EC Pressure Equipment Directive (PED)
  - 94/9/EC ATEX Directive (Electrical/Mechanical)
  - 89/336/EEC The Electromagnetic Compatibility Regulations
  - 73/23/EEC Low Voltage Equipment
  - 93/465/EEC Rules for CE Marking
  - ASME VIII Div 1 U-Stamped Pressure Vessel
  - ASME B31.3 and BS EN 13480 Process Piping
  - ASME B16.5 Pipe Flanges and Fittings
  - ASME V Non-Destructive Testing
  - ASME 1X/BS EN 25817/PED Welding Piping/Weld Acceptance
  - AWS D1.1/BS 5950 Structural Design Fabrication
  - Material Traceability Certification to Section 3.1 of EN-10204
  - Hazardous Area Classification North America Class 1 Div 2
  - Institute of Petroleum Model Code of Safe Practice Part 15
  - Fire Codes – NFPA 72 / NFPA 12
  - Motors, Heaters, and Lights are designed per NEC
  - Package electrical wirings are designed per electrical codes suitable for installation in North America



## 10. Termination Points

Interface Description	Terminal Points
Combustion Air	Inlet to intake filter house.
Compressed / Instrument Air	Compressed air connection at skid edge connections as necessary.
Combustion Air Chiller Coil	Inlet and outlet connections on air filter wall flanged connections as necessary.
Exhaust Gas	The exhaust flange from the gas turbine module.
Ventilation	Enclosure vents outlets.
Mountings	Locations on skid baseplates and all other structural members.
Fuel Gas	Inlet flange on side of gas turbine module and vent flange on gas turbine module.
Liquid Fuel	Inlet and outlet connections on the liquid injection skid and gas turbine module.
Water	Inlet and outlet connections on inlet chiller coil, water injection skid, liquid fuel skid, and gas turbine module as necessary.
Lubricants	Filling points at oil reservoirs. Drains connections at oil reservoirs.
Drains	Drains system connections on all modules as necessary.
Coolant	Inlet and outlet connections on gas turbine skid edge connections as necessary.
Compressor Cleaning	Filling point of wash tanks.
Control and Instrumentation	Serial link connection between HMI and gas turbine module mounted control panels. UCP Terminal blocks in control panels and on-skid connections. GCPP Terminal blocks in control panels and on-skid connections.
Grounding	Grounding terminals on modules and auxiliary skids.
HV Electric Power	Lineside terminals of AC generator. Neutral terminal of AC generator
Medium Voltage Electric Power	At motor terminals inside the package. Motors include, AC generator lube oil pumps, gas turbine control oil pumps, starting motor and enclosure ventilation fans.
Low Voltage Power	Single line connection on the gas turbine module, AC Generator module and CO <sub>2</sub> extinguishant skid.

## APPENDIX B - TECHNICAL SPECIFICATIONS

### Commentary





Rolls-Royce scope of supply is limited to the gas turbine generating set and associated systems necessary for the safe operation of the gas turbine GenSet, as defined in the Appendix A - Scope of Work. Balance of plant, transformers and other equipment and services necessary as stated in the exclusions to complete the plant are not included. The design provided is based on use of equipment supply to Rolls-Royce standard design.

Details for the following interface requirements, functional specification and design conditions are provided. Interface Conditions are provided as preliminary, contract specific information will be submitted as defined in the Rolls-Royce Document Requirements List (SDRL).

The attached Typical General Arrangement Drawing, Inspection and Test Plan (ITP), GER 0144 and GER 0070 form part of this Appendix.



## **TRENT 60 WLE GENSET – INTERFACE REQUIREMENTS**

### **FUEL GAS REQUIREMENTS**

The customer shall provide the fuel gas compression and treatment system required to deliver fuel gas from the pipeline to the gas turbine skid edge interface within the Rolls-Royce fuel acceptability criteria, this includes removal of all potential contamination from the pipeline and gas compression process.

Fuel quality is directly related to the cost and frequency of repair and life of gas turbine components. Unacceptable fuel quality can result in detrimental effects to unit operability, performance, availability, emissions and life and therefore should be avoided.

Good fuel handling practice should always be followed to avoid contamination. As either a secondary measure or in cases where fuel contamination has occurred, fuel treatment should always be considered and put in place as necessary to meet the appropriate Rolls-Royce fuel acceptability criteria.

Equipment for fuel gas supply treatment, such as gas compressors, heaters and coalescers, are usually outside Rolls-Royce scope of supply.

In cases where liquid oil or other liquids are present in gas fuel, installation of purpose built coalescing units is essential. Coalescing units should probably be sited where the gas is at its coldest, to maximize coalescer efficiency, and probably as close as possible to the gas fuel skid to minimize condensation in the pipe work following unit shutdown.

Fuel temperature at entry to coalescing units is critical; coalescer suppliers should be consulted for the appropriate temperature range and advice.

Below table shows the Gas fuel pressure, temperature and usage requirement for Trent 60 genSet:

<b>Pressure (kPag) &amp; Temperature (°C)</b>	<b>Usage</b>
Minimum skid edge fuel gas temperature: Saturated vapor Temp. + ( 20 or 0 which ever is higher) + fuel correction factor (dependent on contract fuel)	Contract Specific
Maximum skid edge fuel gas pressure: Max. 6200 @ 160(°C) Max. 8200 @ 38(°C)	



**Table 1: Trent 60 Fuel Gas Requirements**

<b>Where more than one gas fuel is to be used, where limits are outside these requirements, or where other fuel constituents are present, e.g. hydrogen (H<sub>2</sub>), mercury (Hg), acetylene (C<sub>2</sub>H<sub>2</sub>), methanol (C<sub>2</sub>H<sub>3</sub>OH), ethanol (C<sub>3</sub>H<sub>5</sub>OH), benzene (C<sub>6</sub>H<sub>6</sub>), toluene (C<sub>7</sub>H<sub>8</sub>), heptane (C<sub>7</sub>H<sub>16</sub>)... , dodecane (C<sub>12</sub>H<sub>26</sub>)... , heptadecane (C<sub>17</sub>H<sub>36</sub>) and so on, refer to Rolls-Royce.</b>		
Gas fuel properties (where standard conditions; 15°C (59°F) and 101.325kPa (14.696psia), apply to the fuel gas)	Units	Limits
Lower Calorific, or Heating, Value (LCV or LHV)	kJ/ m <sup>3</sup> (Btu/SCF) kJ/kg (Btu/lb)	29 000 (780) minimum 34 000 (14 600) minimum
Wobbe Index {LCV / (√ SG)}	kJ/ m <sup>3</sup> (Btu/SCF)	34 500 (925) minimum 51 000 (1 370) maximum
Wobbe Index variation to an agreed datum (Minimum and maximum limits must also apply)	%	+/- 5 maximum
Gas fuel constituents	Units	Limits
Methane (CH <sub>4</sub> )	% volume	65 minimum
Ethane (C <sub>2</sub> H <sub>6</sub> )		13.0 maximum
Propane (C <sub>3</sub> H <sub>8</sub> )		7.0 maximum
Butane (C <sub>4</sub> H <sub>10</sub> )		4.0 maximum
Pentane (C <sub>5</sub> H <sub>12</sub> )		0.80 maximum
Hexane (C <sub>6</sub> H <sub>14</sub> )		0.30 maximum
Inert gases, including carbon dioxide (CO <sub>2</sub> ) and nitrogen (N <sub>2</sub> ) – see Note B		Consult Rolls-Royce for project specific inert gas limits
Any form of sulphur, including hydrogen sulphide (H <sub>2</sub> S) and sulphur dioxide (SO <sub>2</sub> ) See Notes C, D, F, G and H	All sulphur entering the gas turbine will affect unit life and will result in SO <sub>x</sub> emissions “sulphur-in = sulphur out”. Consult Rolls-Royce for expected unit life.	
Fuel contaminants / corrosive constituents	Units	Limits
Oil – Concentration	ppm by weight	2 maximum
Oil - Droplet size	10 <sup>-6</sup> m (microns)	0.5 maximum
<b>No other liquids or hydrates are permissible – see Note I</b>		
Particle size	10 <sup>-6</sup> m (microns)	20 maximum
Sodium plus potassium See Notes C, E, F G, H and J	ppm by weight	0.6 maximum
Fuel supply	Units	Limits
Fuel supply conditions (temperature and pressure) at entry to the gas fuel skid See Notes A, B, K, L, M, N, O, P and Q	Consult Rolls-Royce for project specific fuel supply conditions	
Fuel flow variation (at base load) see Note Q	%	+/-0.2 maximum



- Note A: Higher levels and quantities of hydrocarbons, at a given pressure, increase the temperature required to maintain the fuel in the gaseous state. Accurate knowledge of fuel constituents, particularly heavier hydrocarbons is required to ensure the fuel remains fully gaseous.
- Note B: In the majority of cases, the maximum acceptable level of inert gases is approximately 15% volume. However, the maximum acceptable level will depend on the balance of other fuel gas constituents and fuel supply conditions. Rolls-Royce shall be consulted for project specific inert gas limits.
- Note C: Hot section gas turbine materials are susceptible to hot corrosion when certain contaminants such as sulphur, salts, and trace metals are ingested into the gas turbine. This is a metallurgical fact faced by all of the gas turbine industry. Rolls-Royce address this by applying specialised coating materials to components that are prone to hot corrosion caused by sulphur entering via the fuel.
- Note D: Typically sulphur enters the gas turbine via gas fuel in the form of hydrogen sulphide and/or sulphur dioxide. The sulphur level entering the gas turbine is critical for determining the rate of sulphidation of hot section components, which affects unit life. Typically when higher levels of sulphur enter the gas turbine the unit life is reduced.
- Note E: Typically sodium and potassium enter the gas turbine via the intake air in the form of salts and in some cases via the fuel. The level of sodium plus potassium entering the gas turbine is critical for determining the rate of sulphidation of hot section components, i.e. the expected mid life refurbishment for maritime (salty air) applications compared to inland (non-salty air) is significantly lower for a given level of sulphur.
- Note F: Information on air quality and where applicable water injection quality is important for prediction of mid life refurbishment. Further information is provided in the Rolls-Royce water injection acceptability criteria and in the Rolls-Royce definition of clean air.
- Note G: Acceptable limits for sulphur and specified contaminants, such as trace metals, in fuel represent the total amounts permissible to enter the gas turbine. This includes intake air and where applicable injected water. All individual Rolls-Royce limits for fuel, injected water and air must be met.
- Note H: Standard mid life refurbishment for gas fuel applications of 25 000 hours is based on applications where either of the following apply:
- Clean environment; sulphur free, essentially non-salty air, i.e.  $\leq 0.001$  wppm NaCl. Clean gas fuel, i.e.  $\leq 0.027\%$  volume  $\text{H}_2\text{S} + \text{SO}_2$  with no other fuel contaminants.
- Or
- Salty but otherwise clean environment; sulphur free, salty air, i.e.  $\leq 0.01$  wppm NaCl.
- Clean gas fuel, i.e.  $\leq 0.0005\%$  volume  $\text{H}_2\text{S} + \text{SO}_2$  with no other fuel contaminants.
- Note I: The presence of oil, or any liquid hydrocarbons, in gaseous fuel entering the fuel system can cause large variations in heat input. In severe cases, where slugs of liquid accumulate, combustor damage can result. No accumulation or condensation of oil is permitted in the fuel system. Installation of purpose built coalescing units is recommended. Fuel temperature at entry to coalescing units is critical; coalescer suppliers should be consulted for the appropriate temperature range and advice.
- Note J: The maximum limit for sodium plus potassium in the fuel applies to the total amount entering the gas turbine and is based on a fuel with an LCV (or LHV) of 43000 kJ/kg.
- Note K: Customer site-specific gas fuel supply conditions as stated in the contractual agreement apply. In cases where customer conditions have changed, such as fuel composition, Rolls-Royce shall be consulted to re-evaluate the gas fuel supply conditions.
- Note L: The fuel supply at entry to the gas fuel skid must be maintained at a temperature that includes an allowance for cooling; between gas fuel skid edge and the fuel injector outlet.



- Note M: Water content, at a given pressure, will increase the temperature required to maintain the fuel in the gaseous state. Accurate knowledge of water content is required to ensure the fuel remains fully gaseous.
- Note N: Fuel supply temperature must be controlled to ensure good operability of fuel system components such as fuel valves and to ensure that the fuel always remains fully gaseous.
- Note O: Maximum fuel supply temperature is governed by certain components within the fuel delivery system that have maximum limits for which they are permitted to operate.
- Note P: Maximum fuel supply pressure is governed by certain components within the fuel delivery system that have maximum limits for which they are permitted to operate.
- Note Q: Fuel supply pressure fluctuations, at frequencies above 0.5 Hz, caused by pulsations in fuel supply should be avoided as they can cause cyclic oscillations of specific components. In extreme cases fuel supply pressure fluctuations can lead to component failure. The fuel pressure variation limit of  $\pm 0.2\%$  at base load equates to 200kJ/ s for Trent 60 WLE, which is the maximum fuel flow variation allowed for all operating conditions at 50Hz and 60Hz.



## ***TRENT 60 WLE - INTERFACE REQUIREMENTS***

### ***LIQUID FUEL***

The customer shall provide the liquid fuel supply and treatment system required delivering liquid from the storage to the gas turbine skid edge interface within the Rolls-Royce fuel acceptability criteria, this includes removal of all potential contamination from the process.

Fuel quality is directly related to the cost of repair and life of gas turbine components. Unacceptable fuel quality can result in detrimental effects to unit operability, performance, availability, emissions and life and therefore should be avoided.

Poor fuel quality can be the result of purchasing fuel that does not meet the Rolls-Royce fuel acceptability criteria stated herein and/or a result of contamination, which can occur during transportation from the refinery to the site and/or during fuel storage and forwarding.

Applying good practice for handling liquid fuel is very important. A suitable reference document for Fuel management is ASTM-D4418 'Standard Practice for Receipt, Storage and Handling of Fuels for Gas Turbines'.

Fuel must not be transported or stored tanks constructed or containing the following materials; cadmium, copper, nickel or zinc. Storage tanks must also be constructed of corrosion resistant materials and lined to minimise contamination. For further information/advice consult Rolls-Royce.

Storage tank management should include regular drainage to remove any water and sludge, which is essential to prevent the growth of micro-organisms which can lead to blockage of fuel systems and corrosion problems.

Fuel storage tank inlets shall be located at the bottom of storage tanks. Refuelling of tanks shall allow for settling time of 1 hour/foot before fuel can be drawn to for delivery into the gas turbine.

Good fuel handling practice, as stated above, should always be followed to avoid contamination. As either a secondary measure or in cases where fuel contamination has occurred, fuel treatment should always be considered and put in place as necessary to meet the appropriate Rolls-Royce fuel acceptability criteria.

Rolls-Royce must be consulted if any other contaminants other than those specified in Table 2.2 are present, e.g. arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, zinc...

Rolls-Royce should be consulted to agree any proposed fuel treatments.

Rolls-Royce should be consulted and for advice on test methods.

Below shows the Distillate Liquid fuel pressure, temperature and usage requirement for Trent 60 genSet:

- Pressure - 35 – 345 kPag.
- Temperature - Min. 5 above cloud point or 0 which ever is highest. Max. 10 below flash point or 60 which ever is lowest.
- Usage - Min. 4.4 Kg/s and Max. 5.2 Kg/s.



**Table 2: Liquid fuel acceptability criteria paramount to acceptability at entry to the Trent 60 WLE**

Physical properties Paramount to acceptability	Units	Minimum	Maximum	Test method(s) Latest standards apply (Rolls-Royce should be consulted and for advice on test methods.)
Fuels falling outside of these limits must be referred to Rolls-Royce for evaluation				
Aromatic Content	% volume	5	40	ASTM-D1319 / IP156 See Notes a and b
Consult Rolls-Royce where either the total aromatic content is over 25% volume or where control of smoke emissions is a requirement. Additional testing may be required.				
Carbon Residue on 10% bottoms (Conradson or Ramsbottom)	% weight	-	0.35	ASTM-D189 / ASTM-D524 / ASTM-D4530 / IP13 / IP14
Cloud point	Fuel temperature must be at least 5°C above the cloud point throughout the gas turbine fuel delivery system.			ASTM-D2500 / IP219
Distillation data				
10% volume recovery	°C (°F)	-	250 (482)	ASTM-D86 / IP123
90% volume recovery			357 (675)	
Final Boiling Point			385 (725)	
Flash point	Fuel temperature must be at least 10°C below the flash point throughout the gas turbine fuel delivery system.			ASTM-D56 / ASTM-D93 / ASTM-D3828 / IP34 / IP170 See Note c
Smoke point	Mm	17	-	ASTM-D1322 / IP57
Viscosity (Kinematic) – see Figure 1 and Note d	mm <sup>2</sup> /s (centistokes)	1	11	ASTM-D445 / IP71
Fuel supply	Units			
Fuel flow variation (at base load)	%	+/-0.2 maximum See Note e		

Note a: ASTM-D1319 is applicable to 5 to 99% volume aromatics. Samples containing dark-coloured components that interfere in reading of the chromatographic bands cannot be analysed. Rolls-Royce shall be consulted for advice.

Note b: Alternative test methods; ASTM-D5186, IP391 and IP436 can be used to measure % mass aromatic content. Results include both single and multi-ring aromatics and must be reported to Rolls-Royce to access acceptability.

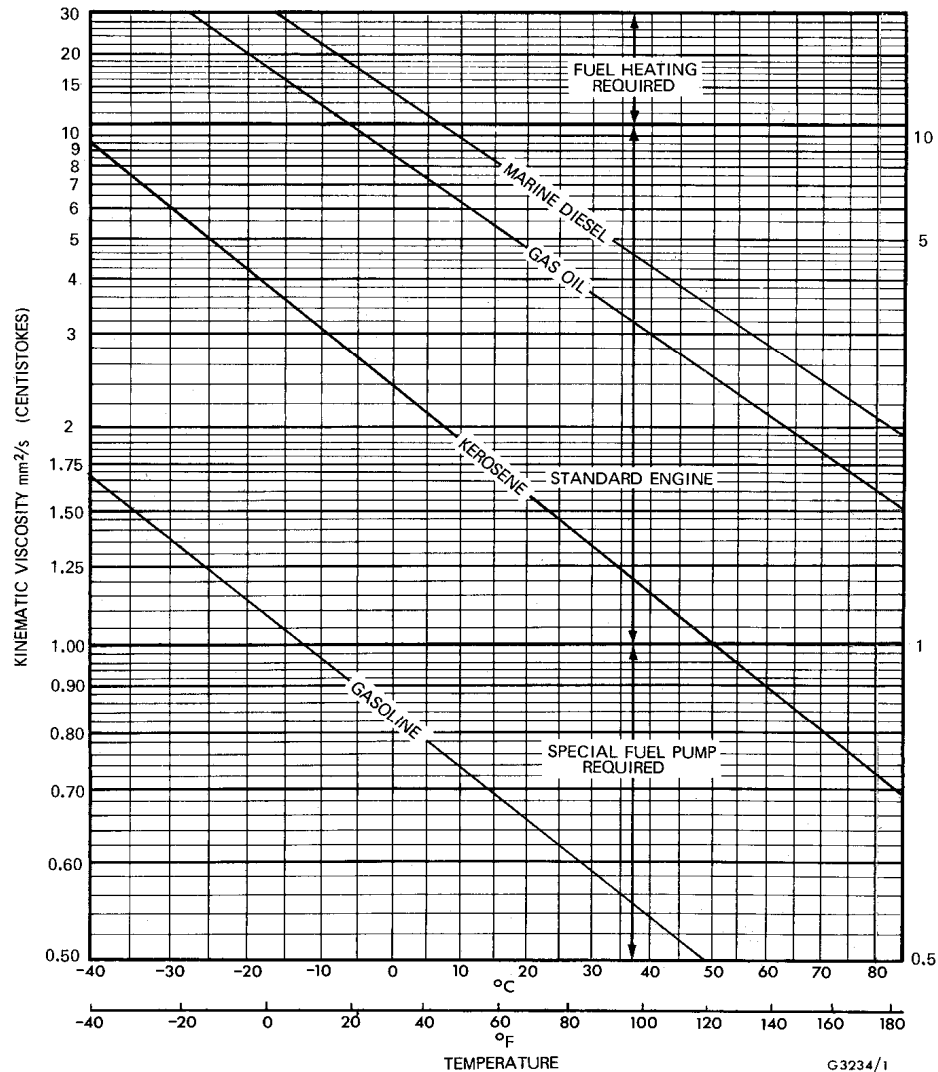
Note c: ASTM-D56 is applicable to liquid fuels with a viscosity below 5.5mm<sup>2</sup>/s (centistokes) at 40°C (104°F), or below 9.5mm<sup>2</sup>/s (cSt) at 25°C (77°F), and a flash point below 93°C (200°F).

Note d: Fuel preheating may be necessary to reduce viscosity and to remove wax from high cloud point fuels. Rolls-Royce should be consulted for advice.



Note e: Fuel supply pressure fluctuations, at frequencies above 0.5 Hz, caused by pulsations in fuel supply should be avoided as they can cause cyclic oscillations of specific components. In extreme cases fuel supply pressure fluctuations can lead to component failure. The fuel pressure variation limit of  $\pm 0.2\%$  at base load equates to 200kJ/ s for Trent 60 WLE, which is the maximum fuel flow variation allowed for all operating conditions at 50Hz and 60Hz.

**Figure 1: Viscosity (Kinematic)– Temperature characteristics for Industrial Gas Turbines**







**Table 3: Liquid fuel acceptability criteria at delivery to the Trent 60 WLE gas turbine – fuel cleanliness limits**

Fuel cleanliness properties Paramount to acceptability	Units	Maximum	Test method(s) Latest standards apply (Rolls-Royce should be consulted and for advice on test methods.)
Fuels falling outside of these limits must be referred to Rolls-Royce for evaluation			
Ash	% weight	0.01	ASTM-D482 / IP4 See Note f
Trace metals - see Notes g, j, k, l and m			ASTM-D3605
Calcium	ppm by weight	0.5	
Lead		0.5	
Sodium plus potassium – see Note i		0.6	
Vanadium		0.5	
Rolls-Royce should be consulted to agree any proposed fuel treatments.			
Sulphur See Notes g, h, j, k, l and m	All sulphur entering the gas turbine will affect unit life and will result in SOx emissions “sulphur-in = sulphur out”. <b>Consult Rolls-Royce for expected unit life.</b>		
	% weight	1.0	ASTM-D129 / ASTM-D1266 / ASTM-D1552 / ASTM-D2622 / ASTM-D4294 / IP61 / IP336 See Notes n and o
Free water and sediment	% volume	0.05	ASTM-D1796 / ASTM-D2709 See Note p
Particulates	mg/ litre	3.0	ASTM-D2276 / ASTM-D5452
	g/ m <sup>3</sup>		ASTM-D6217 / IP415
Particle size	10 <sup>-6</sup> m (microns)	2 micron nominal / 10 micron absolute	
Rolls-Royce must be consulted if any other contaminants are present, e.g. arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, zinc....			

Note f: Both ASTM-D482 and IP4 are applicable to ash in the range of 0.001 to 0.180% from distillate and residual fuels, gas turbine fuels and other petroleum products, which are free from ash-forming additives, including certain phosphorus compounds.

Note g: Hot section gas turbine materials are susceptible to hot corrosion when certain contaminants such as sulphur, salts, and trace metals are ingested into the gas turbine. This is a metallurgical fact faced by all of the gas turbine industry. Rolls-Royce address this by applying specialised coating materials to components that are prone to hot corrosion caused by sulphur entering via the fuel.



- Note h: Sulphur is present in all distillate fuels. The level sulphur level entering the gas turbine is critical for determining the rate of sulphidation of hot section components, which affects unit life. Typically when higher levels of sulphur enter the gas turbine the unit life is reduced.
- Note i: Typically sodium and potassium enter the gas turbine via the intake air in the form of salts and in some cases via the fuel. The level of sodium plus potassium entering the gas turbine is critical for determining the rate of sulphidation of hot section components, i.e. the expected mid life refurbishment for maritime (salty air) applications compared to inland (non-salty air) is significantly lower for a given level of sulphur.
- Note j: Information on air quality and where applicable water injection quality is important for prediction of mid life refurbishment. Further information is provided in the Rolls-Royce water injection acceptability criteria and in the Rolls-Royce definition of clean air.
- Note k: Acceptable limits for sulphur and specified contaminants, such as trace metals, in fuel represent the total amounts permissible to enter the gas turbine. This includes intake air and where applicable injected water. All individual Rolls-Royce limits for fuel, injected water and air must be met.
- Note l: Maximum limits and specified quantities of sulphur and contaminants are based on a fuel with a Lower Calorific Value (LCV) of 43 000kJ/kg (18500Btu/lb) and must be scaled as follows to account for changes in LCV. Hence where the specified maximum limit is 0.5wppm the following applies:
- Acceptable limit =  $0.5\text{wppm} \times \text{LCV (kJ/kg)} / 43\,000\text{kJ/kg}$
- Note m: Standard mid life refurbishment for liquid fuel applications of 16 000 hours is based on applications where either of the following apply:
- Clean environment; sulphur free, essentially non-salty air, i.e.  $\leq 0.001\text{wppm NaCl}$ .
- Clean liquid fuel; i.e.  $\leq 0.05\%$  weight sulphur,  $\leq 0.1\text{wppm}$  sodium,  $\leq 0.1\text{wppm}$  potassium,  $\leq 0.1\text{wppm}$  calcium,  $\leq 0.1\text{wppm}$  magnesium) with no other fuel contaminants.
- Or
- Salty but otherwise clean environment; sulphur free, salty air, i.e.  $\leq 0.01\text{wppm NaCl}$ .
- Clean liquid fuel, i.e.  $\leq 0.001\%$  weight sulphur,  $\leq 0.1\text{wppm}$  sodium,  $\leq 0.1\text{wppm}$  potassium,  $\leq 0.1\text{wppm}$  calcium,  $\leq 0.1\text{wppm}$  magnesium) with no other fuel contaminants.
- Note n: ASTM-D1266 covers the determination of total sulphur in liquid petroleum products in concentrations from 0.01 to 0.4 % weight and also includes a procedure that permits the determination of sulphur in concentrations as low as 5 mg/kg.
- Note o: ASTM-D4294 covers the measurement of sulphur in hydrocarbons, such as Diesel, naphtha, kerosene, residuals, lubricating base oils, hydraulic oils, jet fuels, crude oils, gasoline (all unleaded), and other distillates. The applicable concentration range is 0.0150 to 5.00% weight sulphur.
- Note p: ASTM-D2709 is applicable when fuel viscosity at 40°C is 1.0 to 4.1mm<sup>2</sup>/s and density is 770 to 900 kg/m<sup>3</sup>. ASTM-D1796 should be used for fuels with higher viscosity.



**Table 4: Liquid fuel (indicative) acceptability criteria at delivery to the Trent 60 WLE gas turbine**

Physical properties Good indicators of acceptability	Units	Minimum	Maximum	Test method(s) Latest standards apply (Rolls-Royce should be consulted and for advice on test methods.)		
Fuels falling outside of these limits must be referred to Rolls-Royce for evaluation						
Copper corrosion	-	-	1	ASTM-D130/ IP154		
Density, SG and API - See Note n						
Density at 15°C (59°F) Or	kg/ m <sup>3</sup> (lb/SCF)	600 (37.5)	880 (55.0)	ASTM-D1298	ASTM-D4052 / IP365	IP160
Specific gravity at 15.6/15.6°C (60/60°F) Or	-	0.60	0.88			-
API at 15.6°C (60°F)	-	29.3	104		-	ASTM-D287
Lower Calorific Value	kJ/kg (Btu/lb)	40 700 (17 500)	52 850 (22 720)	ASTM-D4809		
Lubricity, corrected wear scar diameter at 60°C (140°F)	10 <sup>-6</sup> m (in)	-	460 (0.018)	ISO-12156		
Hydrogen content	% weight	12.5	-	ASTM-D1018 / ASTM-D3343 / ASTM-D3701 / IP338		
Neutralisation number Total acid number Strong acid number Strong base number	mg KOH/ g mg KOH/ g mg KOH/ g	- - -	0.5 0.0 0.0	ASTM-D974 / ASTM-D4739 / IP139		
Olefin Content	% volume	-	5.0	ASTM-D1319 / IP156		

Note n: Customer fuel specifications should include Density, Specific Gravity or API Gravity. Information on all three properties is not required, but in cases where more than one property is stated they should all conform to the specified limits.



## **TRENT 60 WLE - INTERFACE REQUIREMENTS**

### **WATER INJECTION**

Rolls-Royce defines the Water Quality requirements as presented below. Water quality falling outside of these limits or where other constituents or contaminants are present, the data needs to be referred to Rolls-Royce for evaluation.

**Table 3: Water acceptability criteria at entry to the Water Injection system**

Acceptable water shall be prepared and controlled in accordance with ASTM-D1193 as Type IIIA or Type IVA and shall meet the requirements specified below – see Notes a and b				
Appearance	Clear and colorless			
Water temperature	Conditions shall be such that no ice or steam forms			
Parameter	Units	Minimum	Maximum	Test method(s) Note c
Acidity Notes d, e, f and g	pH	6.0	8.0	ASTM-D5128 OR ASTM-D5464
Conductivity at 25°C Notes d, e, f, h, i, j and k	µS/cm	-	1.0	ASTM-D5391
Silica Note l	wppm	-	0.05	ASTM-D859 OR ASTM-D4517
Calcium plus magnesium Notes m and l	wppm	-	0.08	ASTM-D3919
Sodium Notes m and l	wppm	-	0.1	
Potassium Notes m and l	wppm	-	0.1	
Total metals (to include sodium, potassium, calcium and magnesium) Notes n and l	wppm	-	0.30	ASTM-D3919 PLUS ASTM-D4190
Chlorides Note l	wppm	-	0.2	ASTM-D4327
Total sulphates, sulphides and phosphates Note l	wppm	-	1.0	ASTM-D4327 PLUS ASTM-D4658
Filtration Notes d, k and o	µm	10 nominal 40 absolute		
Consult Rolls-Royce if any other constituents/contaminants are present. Refer to Note n.				



- Note a: All limits for parameters specified in ASTM-D1193 that are not included in the Rolls-Royce specific requirements, Table 1.1, shall be met.
- Note b: Where parameters are specified in both ASTM-D1193 and the Rolls-Royce specific requirements, Table 1.1, the limits stated in Table 1.1 have precedence.
- Note c: There are numerous tests for measuring water quality parameters, which are often addressed by international standards such as American Society for Testing and Materials (ASTM). Updates to such test methods and the applicability of test range to the defined limit/s is important. Rolls-Royce shall be consulted for advice.
- Note d: On-line monitoring is available for measurement of pH (ASTM-D5128), measurement of conductivity (ASTM-D4519) and measurement of particulates. Consult Rolls-Royce for further advice.
- Note e: Both pH and conductivity measurements are indicative of acceptable water quality.
- Note f: In cases where levels are outside the stated limits, Rolls-Royce shall be consulted.
- Note g: ASTM D5128 and ASTM D5464 are standard test methods for pH measurement of water of low conductivity or on-line and sample analysis respectively. Both methods are applicable to water with conductivity lower than 100 $\mu$ S/cm over the pH range of 3 to 11.
- Note h: Conductivity levels of  $1.0 \geq 1.5 \mu\text{S/cm}$  at 25°C are permissible if all other limits in Table 1.1 are met and confirmed by appropriate sampling results.
- Note i: S = Siemen, 1 Siemen = 1 mho, mho was the old unit.
- Note j: c (centi) = 0.01 = 10<sup>-2</sup>, cm = centimetre.
- Note k:  $\mu$  (micro) = 0.000 001 = 10<sup>-6</sup>,  $\mu\text{S}$  = microSiemen,  $\mu\text{m}$  = micrometer (micron).
- Note l: Limits stated in wppm (weight parts per million) are based on all other individual wppm limits also being met.
- Note m: Limits stated must also be converted into the “effective fuel equivalent”. The total effective amounts entering the gas turbine from all potential sources, water, air and fuel shall be related to the limits stated in the applicable Rolls-Royce fuel acceptability criteria. Consult Rolls-Royce for further advice.
- Note n: Rolls-Royce shall be consulted when metals, elements and compounds in addition to the those specifically stated in Table 1.1 are present. Details shall be reported to Rolls-Royce.
- Note o: Nominal means that the filter will trap at least 98.7% of particles over the stated nominal value, which equates to a Beta ratio of 75, i.e. 1 particle in 75 will pass through the filter. Absolute means that the filter will trap at least 99.5% of particles over the stated absolute value, which equates to a Beta ratio of 200.

Below table shows pressure, temperature and usage requirement for Trent 60 GenSet:

Operating Requirements	Pressure (kPag)	Temperature (°C)	Usage
Water injection	Min. 200 and Max. 600	Min. + 5 and Max. 40	Min. 45 lpm and Max. 341 lpm



## **TRENT 60 WLE - INTERFACE REQUIREMENTS**

### **AMBIENT AIR**

Rolls-Royce defines the Ambient Air Quality requirements as presented below. Ambient air quality falling outside of these limits, or where other constituents or contaminants are present, needs to be referred to Rolls-Royce for evaluation.

**Table 5: Post filtration air contaminant limits for entry into the gas turbine enclosure/intake.**

<b>Air contaminants</b>	<b>Units</b> <i>See Note A</i>	<b>Rolls-Royce air contaminant limits</b> <i>See Note B</i>
Total chloride salts (intake)	ppmw in air	0.001 maximum
Total chloride salts (enclosure)	ppmw in air	0.01 maximum
Particulate matter	mg/m3 microns	0.05 maximum 10 maximum (PM10)

**Table 6: Definition of Clean Dry Ambient Air Quality**

<b>Air constituents/contaminants</b>	<b>Units</b> <i>See Note A</i>	<b>Rolls-Royce acceptable range for clean dry air</b> <i>See Notes B, C and D</i>
Nitrogen (N2)	% Volume	77.5 to 78.5
Oxygen (O2)	% Volume	20.5 to 21.5
Argon (Ar)	% Volume	0.5 to 1.5
Carbon dioxide (CO2)	% Volume	0 to 0.5
Neon (Ne)	% Volume (ppmv)	0 to 0.002 (0 to 20)
Ozone (O3)	% Volume (ppmv)	0 to 0.000 8 (0 to 8)
Helium (He)	% Volume (ppmv)	0 to 0.000 5 (0 to 5)
Methane (CH4)	% Volume (ppmv)	0 to 0.000 2 (0 to 2)
Krypton (Kr)	% Volume (ppmv)	0 to 0.000 15 (0 to 1.5)
Hydrogen (H2)	% Volume (ppmv)	0 to 0.000 1 (0 to 1)
Nitrous oxide (N2O)	% Volume (ppmv)	0 to 0.000 1 (0 to 1)
Carbon monoxide (CO)	% Volume (ppmv)	0 to 0.000 1 (0 to 1)
Xenon (Xe)	% Volume (ppmv)	0 to 0.000 01 (0 to 0.1)
Nitrogen dioxide (NO2)	% Volume (ppmv)	0 to 0.000 01 (0 to 0.1)
Ammonia (NH3)	% Volume (ppmv)	0 to 0.000 001 (0 to 0.01)
Sulfur dioxide (SO2) plus Hydrogen sulfide (H2S)	% Volume (ppmv)	0 to 0.000 002 (0 to 0.02)
Total sulfur (includes SO2 plus H2S)	ppmw	0 to 0.02
Total metals (includes metal content of salts, NaCl, KCl ...)	ppmw	0 to 0.005
Total chlorides (includes chloride content of salts)	ppmw	0 to 0.006

Note A: parts per million by weight (ppmw) =  $1 \times 10^{-6}$



m<sup>3</sup> assumes standard temperature, 15°C (59°F) and atmospheric pressure of 101.325 kPa (14.696 psia).

micron =  $\mu\text{m}$  =  $1 \times 10^{-6}$  m

- Note B: Hot section gas turbine materials are susceptible to hot corrosion when certain contaminants such as sulfur, salts, trace metals are ingested into the gas turbine. Appropriate filtration and materials selection typically accommodate these requirements to ensure expected unit life, performance, operability, reliability, availability and emissions.
- Note C: Gaseous air contaminants, cannot be removed by filtration so in cases where gaseous contaminants are present their expected effect and potential mitigation shall be agreed with Rolls-Royce.
- Note D: Unit life, performance, operability, reliability, availability and emissions as agreed with Rolls-Royce are on the basis of the defined customer site ambient air conditions.
- Note E: All air contaminants/constituents that exceed the defined limits in Tables A and B will not be addressed by the Rolls-Royce standard package. In such cases expected unit life, performance, operability, reliability, availability and emissions will not be ensured unless specific mitigation is agreed with Rolls-Royce.



## **TRENT 60 WLE - INTERFACE REQUIREMENTS**

### **GAS TURBINE COMPRESSOR WATER WASH REQUIREMENTS**

The Trent 60 Power Generation Package requires water, detergent and, for temperate and arctic applications, anti-freeze, to be stored externally and pumped into the holding tanks of the gas turbine compressor water wash cart.

**Table 7: Trent GenSet Gas Turbine Compressor Water Wash Requirements**

Item	Specification
Expected wash frequency	On Condition as required, site-specific
Solution demand per unfired wash	Water 123 liters (32.5 US gal) Anti-freeze 47 liters (12.5 US gal) Cleaning fluid 19 liters (5.0 US gal)

**Table 8: Water Quality Required for Unfired Wash**

Item	Property
Total dissolved solids	< 10 ppmw
Acidity	5 < pH < 7.5
Silica	< 3 ppmw
Specific conductance	< 11 micro-mhos/cm

**Table 9: Recommended Wash Fluids**

GROUP 'A' (no anti-freeze added)	GROUP 'B' (anti-freeze added)
Ardrox 6343	Castrol ICD 177 pre-mixed <sup>1</sup>
Ardrox 6345	<sup>1</sup> Ready-to-use solution can be used down to -32 °C (-26°F). No mixing required.
Ardrox 6366(Turboclean)	
Ardrox 6367(Turboclean)	
RMC G21	Ardrox6373 (Turboclean 2 Wintergrade) <sup>2</sup>
Techniclean GT (ZOK 27)	<sup>2</sup> Ready-to-use solution can be used down to -20°C (-4°F). No mixing required
Techniclean GT-2(Castrol ICD 177)	
Fyrewash F3	

**Table 10: Recommended Anti-Freeze Fluids**

Anti-Freeze Fluid	Anti-Freeze Specifications	Quantities
Methyl Alcohol (MA)	MA to (British Standards) BS506 or 0-M-232G Grade A (US Standard)	20% vol. Max, for a min. temp. -15°C
Isopropyl Alcohol (IPA)	IPA to (British Standards) BS1595 or TT-1735a and 3 Grade B (US Standard)	35% vol. max, for a min. temp. -15°C
Ethylene Glycol (EG)	EG to (British Standards) BS2713 – US Standard not available	40% vol. Max, for a min. temp. -35°C





**Table 11: Unfired Wash Mixture Ratios**  
*Mixing Proportions for Group 'A' Cleaning Fluids (Except R-MC CS)*

Ambient Temperature Range	Alternative Cleaning Fluid (CF) Mixture Ratios					
Above +5°C (+41°F)			CF	20%		
			Demin.Water	80%		
-5°C < T < 5°C (23°F < T < 41°F)	CF	20%	CF	20%	CF	20%
	Demin.Water	70%	Demin.Water	70%	Demin.Water	60%
	MA	10%	EG	10%	IPA	20%
-15°C < T < -5°C (5°F < T < 23°F)	CF	20%	CF	20%	CF	20%
	Demin.Water	60%	Demin.Water	55%	Demin.Water	45%
	MA	20%	EG	25%	IPA	35%
	MA	Methyl Alcohol	EG	Ethylene Glycol	IPA	Isopropyl Alcohol

**Table 12: Unfired Wash Mixture Ratios**  
*Mixing Proportions for Group 'A' R-MC CS Cleaning Fluid*

Ambient Temperature Range	Alternative Cleaning Fluid (CF) Mixture Ratios					
Above +5 °C (+41 °F)			R-MC CS	14%		
			WATER	86%		
-5°C < T < 5°C (23°F < T < 41°F)	R-MC CS	14%	R-MC CS	14%	R-MC CS	14%
	WATER	75%	WATER	74%	WATER	63%
	MA	11%	EG	12%	IPA	23%
-15°C < T < -5°C (5°F < T < 23°F)	R-MC CS	14%	R-MC CS	14%	R-MC CS	14%
	WATER	63%	WATER	60%	WATER	48%
	MA	23%	EG	26%	IPA	38%
	MA	Methyl Alcohol	EG	Ethylene Glycol	IPA	Isopropyl Alcohol

**Table 13: Rinse Fluid Mixture Ratios for Unfired Wash**  
*Mixing Proportions for Group 'A' Rinsing Fluids (Except R-MC CS)*

Ambient Temperature Range	Alternative Rinse Water & Anti-Freeze Ratios					
Above +5 °C (+41 °F)			WATER	100%		
-5°C < T < 5°C (23°F < T < 41°F)	WATER	90%	WATER	85%	WATER	75%
	MA	10%	EG	15%	IPA	25%
-15°C < T < -5°C (5°F < T < 23°F)	WATER	75%	WATER	70%	WATER	55%
	MA	25%	EG	30%	IPA	45%
	MA	Methyl Alcohol	EG	Ethylene Glycol	IPA	Isopropyl Alcohol



## TRENT 60 GENSET – INTERFACE REQUIREMENTS

### COOLING WATER REQUIREMENTS

The Trent 60 Power Generation Package requires cooling water circulation to the gas turbine lube oil cooler, gas turbine hydraulic system cooler, oil mist cooler and AC generator lube oil cooler. The attached GER 0144 provides details for cooling water requirements for Trent 60 GenSet. The information provided in the table below is to indicate the duty required, but will depend on local site conditions.

Operating Requirements	Pressure (kPag)	Temperature (°C)	Usage	Remarks
WACA & Lube Oil	Customer shall maintain a coolant supply pressure at turbine skid edge of 250 +/- 30. Maximum return line pressure at turbine skid edge shall not exceed 50.	Maximum coolant temperature shall not exceed 45	Maximum coolant supply 568 lpm	Heat load: 306 kW Coolant shall contain water and ethylene glycol. Coolant composition shall be determined by customer to assure that coolant does not freeze at site minimum ambient. The coolant shall not contain more than 60% ethylene glycol under any circumstances. Chloride content shall not exceed 50 ppm by weight (60 mg/kg). Filtration of supply water to the exchanger shall be better than 0.5 mm (50 micron) absolute (Beta ratio = 200). See GER0144.
Mineral Lube Oil	Coolant supply pressure shall not exceed 900. Maximum pressure drop in the coolant circuit is 70 at the required coolant flow rate.	Maximum coolant temperature shall not exceed 45	Maximum coolant supply 172 lpm	Heat load: 60 kW Coolant shall contain water and ethylene glycol. Coolant composition shall be determined by customer to assure that coolant does not freeze at site minimum ambient. The coolant shall not contain more than 60% ethylene glycol under any circumstances. Chloride content shall not exceed 50 ppm by weight (60 mg/kg). Filtration of supply water to the exchanger shall be better than 0.5 mm (50 micron) absolute (Beta ratio = 200). See GER0144.
P30 Cooler	Coolant supply pressure shall not exceed 900. Maximum pressure drop in the coolant circuit is 150 at the required coolant flow rate.	Maximum coolant temperature shall not exceed 45	Flow 1050 +/- 50 lpm shall be maintained.	Heat load 265 kW Coolant shall contain water and ethylene glycol. Coolant composition shall be determined by customer to assure that coolant does not freeze at site minimum ambient. The coolant shall not contain more than 60% ethylene glycol under any circumstances. Chloride content shall not exceed 50 ppm by weight (60 mg/kg). Filtration of supply water to the exchanger shall be better than 0.5 mm (50 micron) absolute (Beta ratio = 200). See GER0144.



## ***TRENT 60 WLE - INTERFACE REQUIREMENTS***

### ***OIL & GREASE REQUIREMENTS***

The Trent 60 Package requires synthetic oil for the gas turbine oil systems and mineral oil for the AC generator lube oil system.

**Table 1: Trent GenSet Oil Specification**

Item	Specification	
	Gas Turbine Lube Oil System	AC Generator Lube Oil Systems
Service		
Type	Synthetic Oil	Mineral Oil
Replenish interval	On Condition	On Condition
Approved for use with Industrial Trent	Aeroshell Turbine Oil 500 (ASTO 500) ROYCO Turbine Oil 500 Mobil Jet Oil II Mobil Jet Oil 254 Mobil Jet Oil 291 Exxon Turbo Oil 2197	ISO VG32

- Greases

General greases required for electrical motors, fans, valves, actuator and damper spindles, door hinges and so forth.



## **TRENT 60 WLE - INTERFACE REQUIREMENTS**

### **COMPRESSED AIR REQUIREMENTS**

The Trent 60 Package requires a compressed instrument air supply to the self-cleaning combustion air inlet filter, fuel gas manifold vent valves, water wash system and other pneumatically operated equipment. The following information is forwarded to indicate the likely duty required, but will depend on local site conditions.

**Table 1: Trent GenSet Compressed Air Requirements**

Item	Specification
Nominal delivery pressure	550 - 830 kPa g (80 – 120 psig)
Air quality	Clean and free of water and oil per ISO 8573
Temperature	Minimum 10 to Maximum 50 °C
Dewpoint	-25 °C ( -13 °F)

Instrument air is required for the following systems as detailed in the below table. The instrument air supply is required to provide continuous supply for the Pulse Clean Combustion Filter for anti icing purposes during icing conditions.

**Table 2: Typical Trent GenSet Compressed Air Flow Rate Requirements**

Ambient Conditions = 25°C and 101.325kPa

System	Flow Rate	Duration	Operation Condition	Notes
A) Pulse Air Filter	0.017kg/sec	72 minutes	Typically once per day during continuous operation	A
B) Gas Fuel Purge	0.0085kg/sec	30 seconds	Required during gas turbine start-up on liquid fuel	-
C) Liquid Fuel Purge	0.075kg/sec	2 minutes	Airflow is supplied after emergency/controlled shutdown (ESD/CSD)	-
D) Liquid Fuel Purge	0.057kg/sec	5 minutes	Airflow is supplied sequentially following action (C) after emergency/controlled shutdown (ESD/CSD)	-
E) HP/IP Bearing Purge (ESD only)	0.017kg/sec	90 minutes	Airflow is supplied sequentially following action (D) after emergency/controlled shutdown (ESD only)	B, C
F) ISI Purge	0.017kg/sec	100 minutes	Airflow is supplied sequentially following either: Action (E) for ESD, or Action (D) for CSD	D
G) GT Compressor Water Wash	0.003kg/sec	55 minutes (typically)	Airflow is required to be available during GT wash cycle period	-



Note A: Pulsing intervals may differ for each site and depends on fouling condition of the filters.

Note B: HP/IP bearing purge air requirement will not be required upon successful restart of GT.

Note C: Should the purge air be unavailable, boroscope (and if necessary cleaning procedure) of the GT must be performed after 10 ESD at 10MWe and above.

Note D: 100 minutes purge is only required when one of the following conditions are met.

1. If AIT < 0degC upon shutdown. OR
2. ISI system will remain inactive for more then 5 days after shutdown.



## ***TRENT 60 WLE - INTERFACE REQUIREMENTS***

### ***DRAINS AND VENTS REQUIREMENTS***

The Trent 60 Package has a small number of liquid drains and gas vents that are piped separately to drain collector tanks. These tanks are vented to atmosphere as a quantity of gas is vented via drains on start-up. The table below indicates the main drains supplied.

- Vents

Connections to the Trent 60 Package are made to connections located on the exterior faces of the package, as shown on the general arrangement.

Vent lines must have a continuous vertical rise (no traps or low points).

- Drains

Connections to the Trent 60 Power Generation Package are made to connections located on the exterior faces of the packages, as shown on the general arrangement.



## TRENT 60 GENSET – INTERFACE REQUIREMENTS

### EXHAUST INTERFACE REQUIREMENTS

The exhaust flange from the gas turbine module is provided for onward connection to the Customer's exhaust system.

**Table 14: Trent GenSet Exhaust Interface Customer Connections (Typical)**

Connection	<p>The figure below defines the exhaust interface (M500) which can be oriented vertically.</p> <p>Ø 22.3 60 HOLES EQUALLY SPACED</p> <p>Ø 2870.2 BOLT CIRCLE</p> <p>Ø 2927.1 OUTSIDE FLANGE</p> <p>Ø 2788.6 INSIDE FLANGE</p> <p>CENTER LINE OF FLANGE THERMAL MOVEMENT (COLD TO HOT) MAXIMUM -4.72mm (Y AXIS / AXIAL) +18.49mm (X AXIS / SIDE)</p> <p>DIAMETER THERMAL MOVEMENT (COLD TO HOT) MAXIMUM +15.16mm</p> <p>FLANGE LOAD LIMIT MAXIMUM 340.2 kgf.</p>
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In certain transient conditions the exhaust gas temperature can rise to 480 °C (896 °F). Rolls-Royce therefore recommends that downstream ductwork and equipment are designed for 500 °C (932 °F).

An expansion joint is required to cater for thermal expansion and not alignment mismatch. As such, +/- 10 mm (0.4 in) from the centerline is the alignment tolerance so that the internal silencing bolster can remain effective.

- Exhaust Sound Power Levels Measured

The below table represents the exhaust interface unsilenced Gas Turbine Exhaust Sound Power Data.

**Table 15: Trent GenSet Exhaust Sound Power data**

FREQ. BAND CENTRAL FREQUENCY	Hz	31	63	125	250	500	1000	2000	4000	8000
SWL (1/1 oct)	dB. re.1picowatt	134	139	140	140	139	138	137	137	137



## ***TRENT 60 WLE - INTERFACE REQUIREMENTS***

### ***CIVIL REQUIREMENTS***

Refer to Bolting and Grouting Drawings.

The supply of foundation bolts and all civil is by others.

Grout may be dry pack or wet type





## ***TRENT 60 WLE - INTERFACE REQUIREMENTS***

### ***GROUND (EARTHING) LOCATIONS***

Ground (earthing) pads are located at diagonally opposite corners of the skids. The attached GER 0070 provides details for grounding requirements for Trent 60 GenSet.



## ***TRENT 60 GENSET – INTERFACE REQUIREMENTS***

### ***HV ELECTRICAL TIE-IN***

The generator tie-ins are located on the side of the AC Generator and will be shown on the project specific general arrangement drawing.



## ***TRENT 60 GENSET – INTERFACE REQUIREMENTS***

### ***CONTROL PANELS***

- Package Control System

The Package Control System (PCS) is free-issued for installation in a outside or in a general purpose, control room environment.

- Human-Machine Interface (HMI)

A Human-Machine Interface (HMI) that is linked to the package through a dual redundant network connection remotely controls the GenSet Package. The HMI is free-issued for installation in a general purpose, control room environment.

- Generator Control and Protection panel (GCPP)

The Generator Control and Protection panel (GCPP) is free-issued for installation in a general purpose, control room environment.

- Control Nodes

The MCC (by Others) is controlled and monitored via a motor control system interface module (MCS) linked to the PCS through a dual redundant network connection. The MCS is free-issued for mounting in the MCC during installation.

The GCPP is controlled and monitored via a generator control interface module (GCS) linked to the PCS through a dual redundant network connection. The GCS is free-issued for mounting in the GCPP during installation.

The water injection skid is controlled and monitored via a water injection interface module linked to the EMS through a dual redundant network connection. The WIS is free-issued for mounting at the water injection skid during installation.

The liquid fuel skid is controlled and monitored via a liquid fuel interface module linked to the EMS through a dual redundant network connection. The WIS is free-issued for mounting at the water injection skid during installation.



## ***TRENT 60 WLE - INTERFACE REQUIREMENTS***

### ***CONTROL SYSTEM INTERFACE REQUIREMENTS***

A dual Ethernet LAN is used for the onward link between the HMI system and the Customer's Station Control System (SCS). The following discrete signals will interface to the Station Control System.

From Station Control System to Genset Control System:

- Start
- Stop
- Base selection
- Peak selection
- Fast loading
- Normal loading
- Isochronous mode
- Droop mode
- Speed / load raise
- Speed / load lower
- Voltage raise
- Voltage lower
- Synch reset
- From Genset Control System to Station Control System:
  - Ready to start
  - Load limit
  - Unit running
  - Failure to auto synch
  - Failure to start
  - Breaker closed
  - Start in progress
- The following signals need to be hardwired into the on base control system:
  - From Station Control System to Genset Control System:
    - Plant emergency shut down
    - Trip generator breaker
  - From Genset Control System to Station Control System:
    - GenSet trip

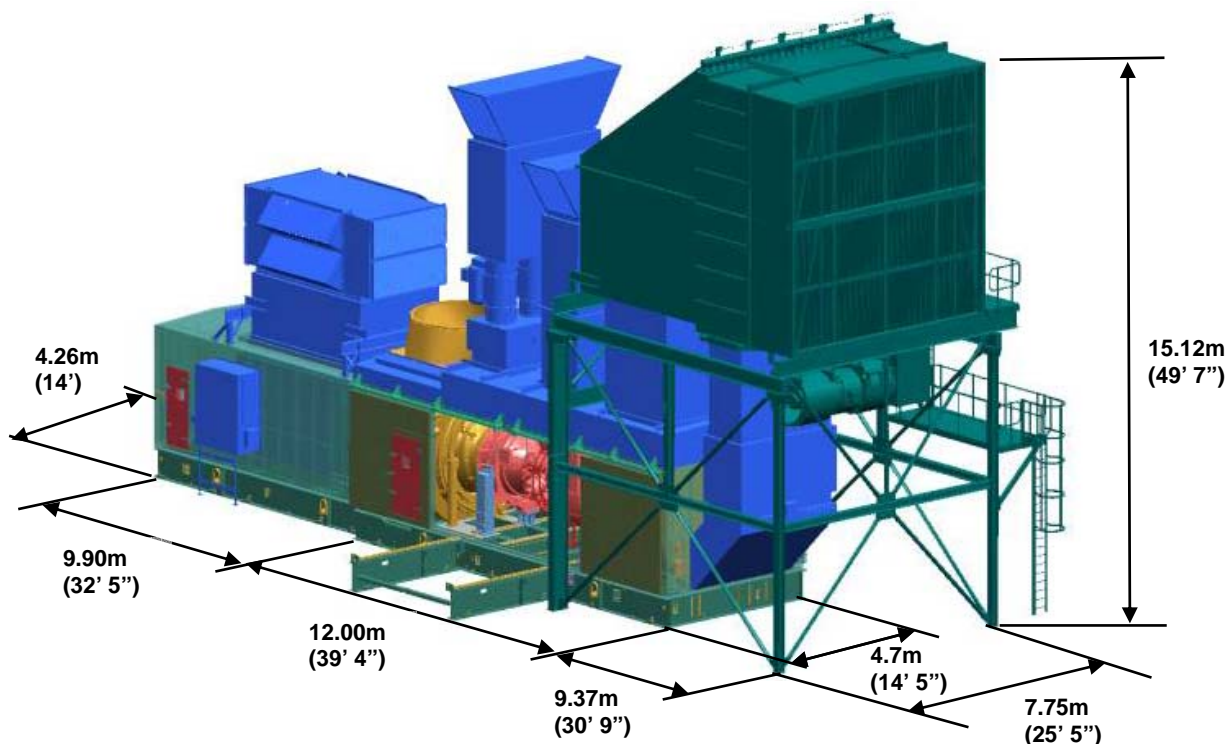


## **TRENT 60 WLE - PACKAGE** **FUNCTIONAL SPECIFICATION**

The Trent 60 Driver Package will provide a package in which all components and subsystems have been carefully selected and optimized to support the Trent 60 WLE Gas Turbine in the form of a compact package, housed within enclosures, and designed to comply with environmental requirements.

The package is designed for quick installation and easy maintenance in the field. Since most of the systems are mounted on the base they can be tested in the factory shop before shipment to the field.

**Figure 1: Typical Trent 60 WLE Package**



The Trent 60 WLE Package is supplied as major modules; with the mechanical auxiliary systems and control systems to support the Trent 60 Gas Turbine mounted on a baseplate and AC Generator mounted on the concrete plint, air systems mounted on the gas turbine enclosures, and water injection skid alongside the package.

The Trent 60 Package encompasses the following major components:

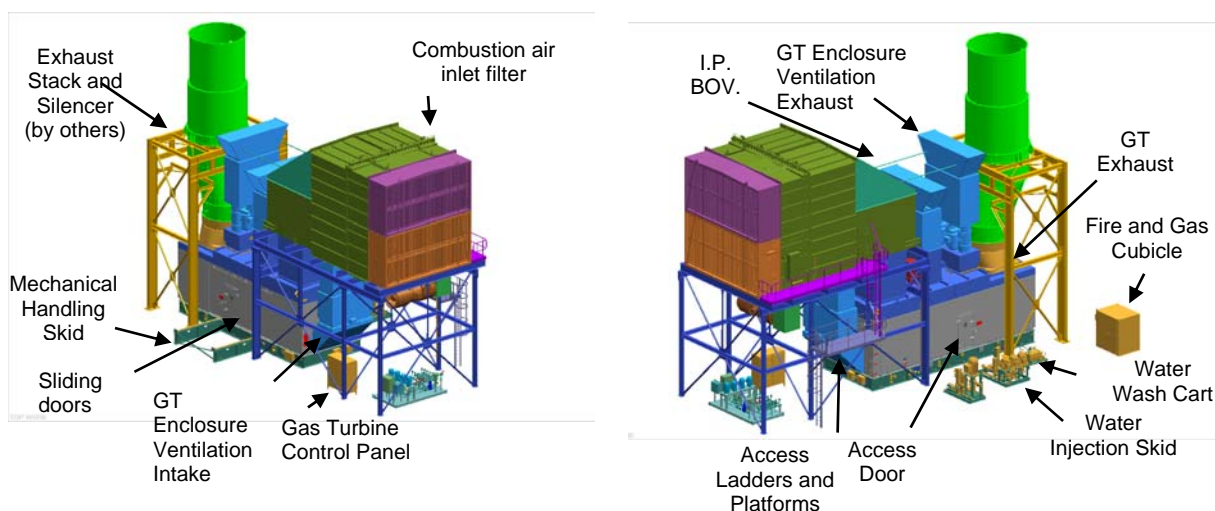
- a. Gas Turbine Module - This module houses the gas turbine, the turbine thrust bearing cooling air heat exchanger, inlet air scroll, exhaust transition duct and diffuser volute, engine mounting and removal arrangement, fuel distribution system, fire protection and gas detection devices, and gas turbine synthetic lubricating oil, hydraulic control oil, and hydraulic start oil systems.
- b. AC Generator Module - The AC Generator is self-contained and encompasses the AC generator, exciter and line / neutral cubicles, mounted on a concrete plinth. The generator is designed to provide the required acoustic performance with cladding and no enclosure. The AC generator mineral lube oil system is located off skid. It is mounted on a concrete plinth that is separately mounted in line with the gas turbine base.



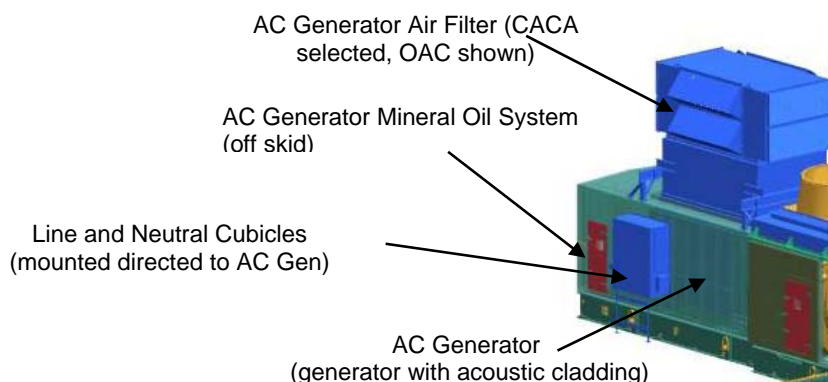
- c. Control System – Located though the package as distributed IO with the package and control system requiring a control panel in the control room with limited interconnection to the Gas Turbine Module. These control cabinet include the Engine Control System (ECS), Package Control System (PCS), fire and gas system and safety related systems, with the remote HMI's, allowing complete control, are mounted in the remote control room.
- d. Air Inlet System - The inlet air filtration system is self supported by a dedicated support structure. Air for both the turbine and enclosure purging is filtered by self-cleaning pulse type filter elements. The system includes all necessary ductwork and silencing systems.
- e. CO<sub>2</sub> bottles are rack mounted in weatherproof enclosures and set onto prepared foundations, and provide extinguishant protection to the gas turbine enclosure.
- f. The Water Injection system is located on separate skid external to the gas turbine package mounted onto prepared foundations.

Each of these modules provides a distinct series of functions that in combination enable the package to operate. The following diagrams shows the layout external and internal to the package.

**Figure 2: Trent 60 WLE Dual Fuel Driver Module (Left side external, Dual Fuel Package)**

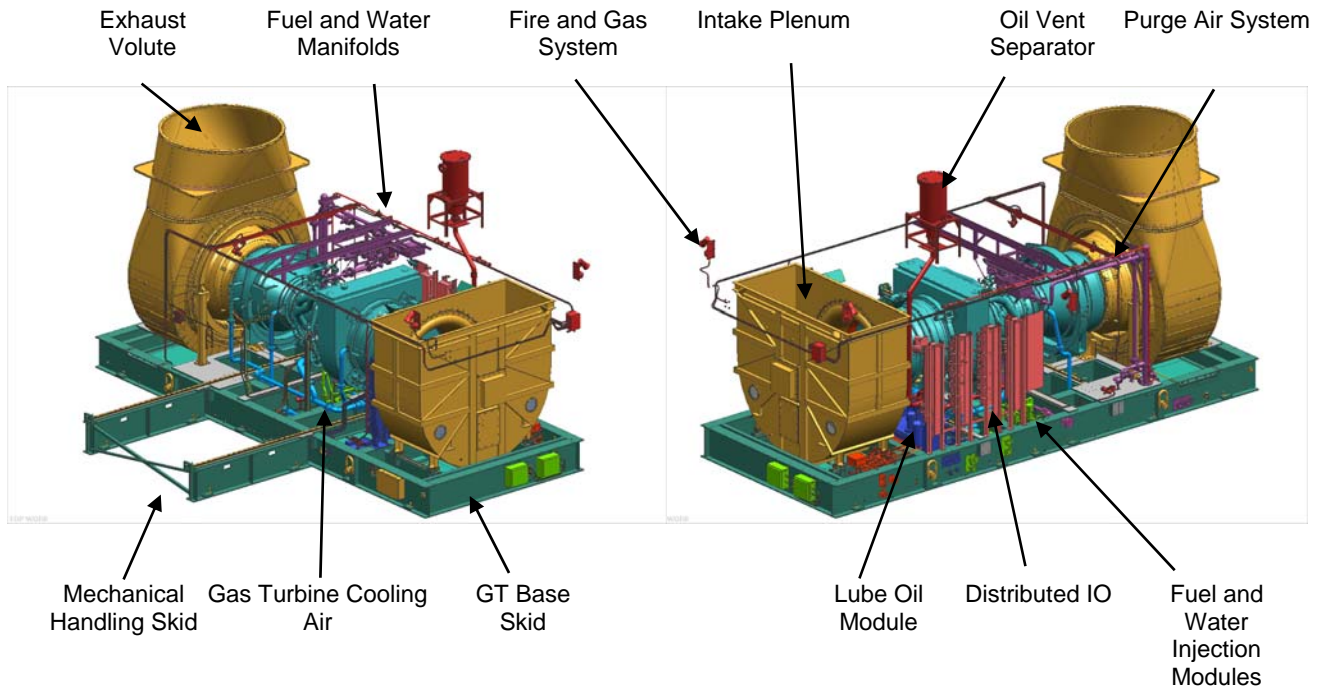


**Figure 3: Trent 60 WLE AC Generator Module**

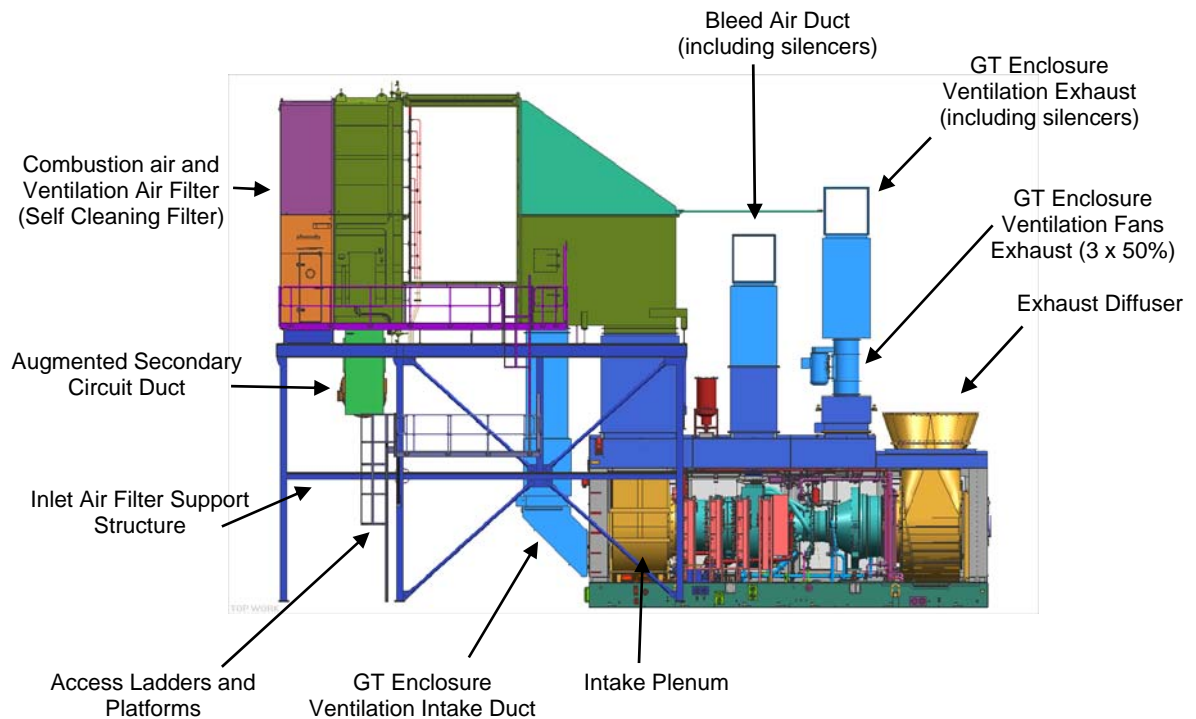




**Figure 4: Trent 60 WLE Driver Module (Inside enclosure, Dual Fuel Package)**



**Figure 5: Trent 60 WLE Dual Fuel Driver Module (Cross Section of Gas Path, Dual Fuel Package)**





## MAJOR PLANT EQUIPMENT SUMMARY

A brief review of each major component of the Trent 60 Power Generation Package follows:

### ***TRENT 60 GENSET***

#### **Gas Turbine**

The industrial Trent 60 gas turbine is a three spool design has evolved from the successful family of RB211 aero and industrial engines. The prime mover consists of three basic elements:

The axial flow compressor sections - There are three separate sections of compression in the Trent 60 gas turbine. Each compressor section operates at its own optimum speed and is driven by its own corresponding turbine section. The inlet to the Low Pressure compressor of the gas turbine includes a set of variable geometry stators to control airflow into the engine. The inlet to the Intermediate Pressure compressor also contains three rows of variable geometry stator blades.

The turbine sections - Three independently operating turbine sections match with their front end compressor sections. The High Pressure and Intermediate Pressure turbine rotors are free to operate at their optimum speeds to achieve the best engine efficiency. The Low Pressure rotor acts as the main power turbine driving the Low Pressure compressor and the AC generator.

Combustion System - Fuel is injected into the combustors from the fuel manifolds in a controlled manner by the Engine Control System (ECS).

These three elements are combined into a single assembly that is shipped complete, with rotors in place, for installation in the gas turbine enclosure.

#### **AC Generator and Exciter**

The open air cooled AC generator and the air-cooled brushless exciter design is mounted on a concrete plinth along with the AC Generator mineral lube oil system.

#### **Gas Turbine Acoustical Enclosure**

The gas turbine enclosure walls are fabricated from steel plate, backed by insulation and a perforated liner, providing attenuation of the noise generated within the enclosure by the machinery.

The enclosure is weatherproof structures with easy access to the equipment and systems installed. Routine maintenance, inspection and cleaning can be performed within the enclosure.

The enclosures are completely wired; AC powered lamps provide normal lighting. Emergency exit hardware is provided on all exterior doors.

#### **Inlet Air System**

The air inlet system consists of a top mounted, self-cleaning inlet filter, self-supported from a dedicated structure, which will deliver filtered air to the Trent 60 gas turbine and the enclosure via ductwork and an inlet silencer. The gas turbine inlet air is guided into the engine by a radial intake scroll which is mounted within the gas turbine module. The self cleaning air filter will use compressed air supplied by others for periodic cleaning of the air filter cartridges when the pressure drop across the air filter exceeds a certain set point.





## Gas Turbine Enclosure Ventilation Systems

The gas turbine enclosure ventilation air system performs two main functions. The primary function is to cool and ventilate the gas turbine enclosure to maintain the enclosure temperature within acceptable limits. However, the ventilation air system also dilutes any concentrations of fuel gases that may occur.

An induced draft system draws filtered air through the gas turbine enclosure via a separate stream of air drawn through the gas turbine combustion air filter.

## Gas Turbine Exhaust system

The gas turbine exhaust system discharges the combustion exhaust gas to atmosphere either directly through an exhaust stack and silencer (both by others).

## Gas Turbine Fuel System

Gas fuel (is supplied to the gas turbines for combustion from skid edge via a self-contained gas fuel metering skid. The electronic Engine Control System (ECS) controls the fuel flow demand to each of the manifolds in order to govern the engine output speed, power and emissions, using inputs from the gas turbine and operator control panel.

Water is supplied to the combustors for emissions control via a self-contained water injection metering skid. The system takes the supply of low pressure demineralized water, providing the pressurized, flow control, filtration and return back.

## Gas Turbine Synthetic Oil Systems

The gas turbine lube oil system provides synthetic turbine oil to cool and lubricate the gas turbine internal gearbox, external gear box, forward bearing, HP/IP bearing, and turbine bearing through an on engine driven pump. This is a closed loop system which filters and cools the oil.

The gas turbine hydraulic oil system provides constant high pressure synthetic turbine oil provided by an on skid variable displacement pump to operate the low pressure compressor bleed valve actuators, low pressure compressor inlet guide vane actuators, intermediate pressure compressor variable stator vane actuator, low pressure thrust piston actuators, and intermediate pressure thrust piston actuators.

The electric start motor cooling oil system provides synthetic turbine oil to the electric start motor bearings and spline which keeps these components lubricated and cool. The electric start motor has the ability to spin at high speeds allowing it to be directly coupled to the gas turbine external gearbox requiring an on skid supply and scavenge pump to constantly circulate oil. The oil scavenged from the electric start motor is pumped into the gas turbine lube oil return before the cooler.

All three systems are closed loop and share one common reservoir. This reservoir is equipped with internal fill facilities, heater, a breather/coalescer system and an oil consumption monitor. The fill filter is located to the front of the reservoir with a quick disconnect fitting for easy filling

## Cooling Water System

The Modules are provided with plate type water to oil heat exchangers for use as oil coolers. The baseplate mounted heat exchangers are designed to provide the cooling needs of the gas turbine synthetic oil systems and AC generator mineral lube oil system described above.



## Gas Turbine Compressor Mobile Water Wash Cart

The gas turbine compressor water wash system is located on a mobile cart that can be moved between units. Two compressor water wash cart are supplied.

The system provides a means of removing contaminants deposited on the rotating and stationary blades of the gas turbine compressor by injecting cleaning chemicals into the blade path via nozzles located in the inlet scroll.

The wash cycle is executed unfired, cranking the gas turbine using electric start system.

The system comprises one tank storing a mixture of de-mineralized water, detergent and anti-freeze. Delivery is via pressurizing the fluid with a compressed air driven pump.

## Fire Protection System

A high pressure CO<sub>2</sub> fire protection system is provided for the gas turbine enclosure. A fire in either of these areas will initiate the fire protection system in that area only and shut down the package.

A two shot system is provided for the gas turbine enclosure.

The fire protection system will give visual indication of actuation at the fire control panel, with repeat alarm facility to the main plant control system.

## Control Systems

The control and protection systems permanently monitor the operating conditions of the plant. The control system adjusts plant parameters according to the operating conditions.

The Human Machine Interface (HMI) is a single point of access to view operation, maintenance and historical data.

The Engine Control System (ECS) provides direct control of the Gas Turbine. The Package Control System (PCS) provides control over all Gas Turbine auxiliary systems and interfaces with the Human Machine Interface (HMI), Engine Control System (ECS), Generator Control and Protection Pane (GCPP), and customer control systems. The Generator Control and Protection Panel (GCCP) provide direct control of the AC Generator.

## Start Time

The start-up sequence time, for a simple cycle Trent 60 Power Generation Package is less than 10 minutes from pressing the start button to reaching full baseload. This includes an allowance for simple cycle exhaust system purge.



## TRENT 60 WLE - PACKAGE

### DESIGN CONDITIONS

Component	Requirements
Ambient temperature range	0°C to +40 °C
Dust / Particulate Loading	Up To 0.05 mg/m3
Elevation	0 to +1000 m asl (0 to +3280 ft asl)
Seismic Level (UBC) [for the ground mounted equipment.]	UBC Zone 3
Design Rainfall	125 mm/hr (4.9 in/hr)
Snow Loading	146 kg/m2 (30 lb/ft2)
Wind Loading	160 kmph (100 mph) / 200 kmph (120 mph) gusts
Saline Concentration	0.01 ppm
Design acoustic level near field [at 1000 mm (3.3 ft) @ 1500 mm (5 ft) above grade]	85 dB(A) [avg.] 90 dB(A) [max.] (see note below)
Design acoustic level far field [at 100 m (330 ft) @ 1500 mm (5 ft) above grade]	65 dB(A)
Ambient Air	R-R Interface Specification
Natural Gas	R-R Interface Specification
Water Injection	R-R Interface Specification

Note: Noise measurements shall be conducted on a walk around survey at all major equipment locations at an elevation of one meter (3 feet) away from the unit and one and one-half meter (five feet) above grade or equipment platforms. The arithmetic average of the survey results shall not exceed 85 dB(A). The maximum level at any single location shall not exceed the stated level.



## **APPENDIX C - PAYMENT SCHEDULE, DELIVERY AND DOCUMENTATION SCHEDULE**

- Base Scope of Supply and Price**

Pricing detailed in this section is for supply to the terms and conditions detailed in base scope of supply:

1.	Supply of Two (2) Trent 60 generating set packages consisting of Trent 60 Gas Fuel Turbines, Self-cleaning (pulsed) combustion air intake filter, exhaust volute, Open air cooled (OAC) AC Alternator and auxiliaries per the Scope of Supply Section of the proposal.	
2.	Supply of Natural Gas Fuel and Distillate #2 Liquid Fuel Combustion System	
3.	All documentation, drawings, data, brochures, software, and factory training	
4.	Commissioning spares	
5.	Delivery EXW from manufacturer's site	
<b>BASE PRICE</b>		<b>\$44,000,000</b>

- Currency**

All prices quoted in this proposal are stated in US Dollars unless indicated to the contrary.

- Payment Schedule**

<b>Payment Due Date</b>	<b>Unit 1</b>	<b>Unit 2</b>
Contract Signature	\$8,260,000	\$8,260,000
6/30/2010	\$2,760,000	\$2,760,000
7/30/2010	\$2,760,000	\$2,760,000
8/30/2010	\$2,760,000	\$2,760,000
9/30/2010	\$2,760,000	\$2,760,000
Upon Readiness to Ship GT Engine (estimated to be 10/30/2010)	\$2,200,000	\$2,200,000
Upon submittal of Documentation per SDRL and Readiness to Ship Commissioning Spares (estimated to be 12/16/2010)	\$500,000	\$500,000

- Commercial Notes**

- i. The initial down payment shall be due within three (3) Days of Contract signing. Invoices will be issued prior to the payment due date. All payments are due via wire.
- ii. Payments due are escalated 1.5% per month, pro-rated for partial months, from the original amount, for past due receipt of payment.
- iii. Delivery will require timely payment in accordance with the Payment Schedule. Delivery of the GT Engine(s) requires payment before release for shipment.



- iv. Pricing does not include sales, value added, personal property, title transfer and other such taxes, if applicable, nor does it include permit fees.
- v. Not Used.
- vi. Technical Direction of Installation and Commissioning is excluded.
- vii. Not Used.

- **Guaranteed Delivery Schedule:**

The following Delivery Dates are based on EXW point of manufacture facility and are applicable to this Contract.

Item	Equipment	Unit 1	Unit 2
1	GT Package	30-Aug-10	30-Sep-10
2	Air Filter	30-Aug-10	30-Sep-10
3	AC Generator	30-Aug-10	30-Sep-10
4	Water Injection Skid	30-Aug-10	30-Sep-10
5	Liquid Fuel Forwarding Skid	30-Aug-10	30-Sep-10
6	Enclosure Direct Ship Items	30-Aug-10	30-Sep-10
7	Mineral LO Console	7-Sep-10	30-Sep-10
8	Generator Neutral Cubicle	30-Aug-10	30-Sep-10
9	Generator Line Cubicle	30-Aug-10	30-Sep-10
10	GT Engine	16-Dec-10	31-Dec-10

- **Documentation Delivery Schedule:**

The attached Rolls-Royce Document Requirements List (SDRL) document scope and dates are applicable to this Contract and form part of this Appendix. The SDRL document commitment is in terms of weeks from down payment received by RR.



## ***APPENDIX D - GUARANTEED PERFORMANCE LEVELS AND LIQUIDATED DAMAGES***

- **Liquidated Damages:**

If the Equipment fails to meet Guaranteed Delivery Dates or the Performance Levels during Performance Tests, Rolls-Royce will pay Customer the sums set out below, on a per unit, pro rata basis, as liquidated damages in full and final settlement of claims arising:

Delivery	<b>0.5% of the Contract Price allocated to the offending Gas Turbine-Generator per full week (prorated to the nearest day on the value of the particular piece of equipment that is delayed); with a cap of 10% of the Contract Price allocated to such Gas Turbine-Generator.</b>
Power output:	<b>0.5% of the Contract Price allocated to the offending Gas Turbine-Generator per 1% shortfall, with a cap of 5% of the Contract Price allocated to the offending Gas Turbine-Generator</b>
Heat Rate:	<b>0.5% of the Contract Price allocated to the offending Gas Turbine-Generator per 1% excess, cap of 5% of the Contract Price allocated to the offending Gas Turbine-Generator</b>
Aggregate Cap:	<b>10.0% of the Contract Price allocated to the offending Gas Turbine-Generator in the aggregate for failure to meet the Guaranteed Delivery Dates or the Performance Levels.</b>

Notes: For the purposes of this provision, each Gas Turbine-Generator has an allocated Contract Price of USD\$22,000,000

- Guaranteed Performance Levels:**

<b>PERFORMANCE DEFINITIONS</b>	
<b>1 - Gross Power Output</b>	The Gross Unit power output when operating at the defined guarantee conditions and fuel specification is guaranteed to be no less than the value stated. Gross Unit Power is taken to mean the output at generator terminals, net of excitation losses and exclusive of power for continuously running Unit essential auxiliary loads.
<b>2 - Gross Heat Rate</b>	The average gross heat rate when operating at the defined guarantee conditions and fuel specification is guaranteed to be no greater than the value stated. The gross heat rate is defined as (fuel heat input [LHV basis] / Gross Unit Power Output)
<b>PERFORMANCE TESTS</b>	
With mutual agreement between the Customer and Rolls-Royce, performance acceptance tests will be conducted to demonstrate compliance with contractual performance guarantees. A Performance Test schedule will be prepared by Rolls-Royce, agreed with the Customer, and included in any subsequent contract documentation, post contract award. The tests will be conducted in accordance with the Rolls-Royce standard test procedure STP G.7.W	
<b>PERFORMANCE TEST MANPOWER</b>	
The performance tests will be carried out by the Customer's manpower or third party authorized institution at the Customer's expense. Rolls-Royce will witness with the performance test.	
<b>Correction to guarantee reference conditions</b>	
The test measured output and heat rate will be corrected to the guarantee reference conditions above using correction procedure supplied with the performance test procedure.	
<b>Plant degradation</b>	
The performance guarantees are based on the GenSet being in a new and clean condition, and the performance test will be performed during the first 100 hours of fired running. If the tests are delayed for any reason, then a degradation allowance will be applied to the corrected test performance before comparison with the relevant guarantees. The gas turbine will be subjected to a compressor soak wash prior to testing. The degradation allowance with time will be established from curves to be provided with the test schedule.	
<b>Test Measurements</b>	
Sufficient measurements will be taken to derive the fully corrected GenSet output and heat rate for comparison with the above guarantees. Additional measurements will be taken to determine the performance of the principal items of plant for information purposes.	



- Natural Gas Performance Guarantees:**

**[TO BE DETERMINED UPON REVIEW OF SITE CONDITIONS]**

The following performance parameters supersede all previously issued guarantees, and are guaranteed at a the Reference Conditions for Guarantee Performance described in this document, unless otherwise stated in the conditions column.					
Parameter	Unit	Value	Conditions	Fig	Definition
Gross Power	kWe	XX	New and Clean, Base load operation	-	1 - Gross Power
Gross Heat Rate (LHV)	kJ/kWe.hr	XX	New and Clean, Base load operation	-	2 - Gross Heat Rate
REFERENCE CONDITIONS					
Site Conditions			Natural Gas Fuel		
Ambient temperature (Dry Bulb)	°C	XX	Methane (CH <sub>4</sub> )	% mol	XX
Relative Humidity	%	XX	Ethane (C <sub>2</sub> H <sub>6</sub> )	% mol	XX
Ambient pressure	kPa	XX	Propane (C <sub>3</sub> H <sub>8</sub> )	% mol	XX
Altitude - For Information only	m asl	XX	i-Butane (C <sub>4</sub> H <sub>10</sub> i)	% mol	XX
Electrical System			n-Butane (C <sub>4</sub> H <sub>10</sub> n)	% mol	XX
Power Factor at generator terminals	-	XX	i-Pentane (C <sub>5</sub> H <sub>12</sub> i)	% mol	XX
Generating frequency	Hz	XX	n-Pentane (C <sub>5</sub> H <sub>12</sub> n)	% mol	XX
Generating voltage at generator terminals	kV	XX	Hexane (C <sub>6</sub> H <sub>14</sub> )	% mol	XX
Gas Turbine			Nitrogen (N <sub>2</sub> )	% mol	XX
Gas Turbine	-	Trent 60	Carbon Dioxide (CO <sub>2</sub> )	% mol	XX
Combustion System	-	WLE			
Configuration	-	Dual Fuel	Fuel LHV	kJ/kg	XX
Operation	-	Base continuous	Fuel Supply / Water Supply		
Condition	-	New and Clean	Fuel Gas Pressure (Guarantee Point)	bar (a)	XX
Operating Hours	hr	< 100 fired	Fuel Gas Temperature (Guarantee Point)	°C	XX
Design Temperature	°C	15 (Gas Fuel)	Water Pressure (Water Injection)	bar (a)	XX
Inlet Installation Losses (Guarantee Point)	mm H <sub>2</sub> O	XX	Water Temperature (Water Injection)	°C	XX
Exhaust Installation Losses (Guarantee Point)	mm H <sub>2</sub> O	XX	Water Pressure (Evap Cooler)	bar (a)	XX
Inlet Cooling	-	None	Water Temperature (Evap Cooler)	°C	XX
Inlet Cooling Operational	-	N/A	Performance Guarantees Definitions		
Performance Deck	-	eTrent v7.1.2	Definitions	Performance Definitions – Appendix D	
Performance Test			Units	SI Units	
Protocol	STP No. G.7.W		Natural Gas Quality	Interface Definition - Appendix B	
Correction Curves	eTrent Method		Ambient Air	Interface Definition - Appendix B	
Instrument Tolerance:	ASME PTC19.1		Water Quality	Interface Definition - Appendix B	





- Liquid Fuel Performance Guarantees:**

**[TO BE DETERMINED UPON REVIEW OF SITE CONDITIONS]**

The following performance parameters supersede all previously issued guarantees, and are guaranteed at a the Reference Conditions for Guarantee Performance described in this document, unless otherwise stated in the conditions column.					
Parameter	Unit	Value	Conditions	Fig	Definition
Gross Power	kWe	XX	New and Clean, Base load operation	-	1 - Gross Power
Gross Heat Rate (LHV)	BTU/kWe.hr	XX	New and Clean, Base load operation	-	2 - Gross Heat Rate
REFERENCE CONDITIONS					
Site Conditions			Liquid Fuel		
Ambient temperature (Dry Bulb)	°C	XX	Specification attached below		
Relative Humidity	%	XX			
Ambient pressure	kPa	XX			
Altitude - For Information only	m asl	XX			
Electrical System					
Power Factor at generator terminals	-	XX			
Generating frequency	Hz	XX			
Generating voltage at generator terminals	kV	XX			
Gas Turbine					
Gas Turbine	-	Trent 60			
Combustion System	-	WLE			
Configuration	-	Dual Fuel	Fuel LHV	kJ/kg	XX
Operation	-	Base continuous	Fuel Supply / Water Supply		
Condition	-	New and Clean	Liquid Fuel Pressure (Guarantee Point)	psi (g)	XX
Operating Hours	hr	< 100 fired	Liquid Fuel Temperature (Guaran. Point)	°F	XX
Design Temperature	°C	15 (Gas Fuel)	Water Pressure (Water Injection)	psi (g)	XX
Inlet Installation Losses (Guarantee Point)	mm H2O	XX	Water Temperature (Water Injection)	°F	XX
Exhaust Installation Losses (Guarantee Point)	mm H2O	XX	Water Pressure (Evap Cooler)	psi (g)	XX
Inlet Cooling	-	None	Water Temperature (Evap Cooler)	°F	XX
Inlet Cooling Operational	-	N/A	Performance Guarantees Definitions		
Performance Deck	-	eTrent v7.1.2	Definitions	Performance Definitions – Appendix D	
Performance Test			Units	SI Units	
Protocol	STP No. G.7.W		Liquid Fuel Quality	Interface Definition - Appendix B	
Correction Curves	eTrent Method		Ambient Air	Interface Definition - Appendix B	
Instrument Tolerance:	ASME PTC19.1		Water Quality	Interface Definition - Appendix B	



## ***APPENDIX E - SCHEDULE OF CUSTOMER SUPPLIED ITEMS***

Rolls-Royce does not accept responsibility for items or aspects of equipment which are outside the Scope of Supply defined above. The following items are excluded from this proposal, unless offered as an option.

- Site earthing / grounding
- Lightning protection
- Compressed air supply and piping
- All auxiliary power supplies, batteries and charger / UPS
- All first fills
- All fuel supplies, fuel supply and treatment
- Block and Bleed Valve
- Water supply and treatment
- Installation, commissioning, site test labor
- Demolition and/or removal of any existing equipment, structures and concrete.
- Installation tooling
- Instrumentation for Site Performance / Operational Testing
- Site facilities
- Fire sprinklers or other fire protection devices which may be required by insurance requirements, laws, or regulations
- Motor Control Center
- Battery Back Up System
- Switchgear
- Transformers (Auxiliary & Main)
- Control system Environmental housing, external to gas turbine package enclosure mounted equipment
- Enclosure Door /Roof Access Ladders / Platforms / Walkways / Stairways and Handrails.
- Control System integration with plant DCS
- Black Start / Emergency GenSet
- Backup lighting power supply/batteries
- Fiscal metering
- Operating and strategic spares beyond those offered in Scope of Proposal
- Civil engineering design, embedments and civil works, grout
- Erection of equipment, rigging, cranes, or other lifting equipment
- Long Term Storage of any supplied equipment
- All interconnecting pipework and cabling, beyond termination points, including:
- All power, signal, control, or other wiring to and from skids or Customer supplied equipment
- Piping between externally (with respect to the Gas Turbine Package) mounted skids and engine baseplate.
- Local Lighting
- Stack, Expansion Joint, Stack Lighting, Grounding Protection System, emissions sampling points or CEMS
- Partial Discharge Monitoring for AC Generator
- Disturbance Recording equipment
- Transportation beyond location specified in Base Scope of Supply.
- Unloading at site and delivery points
- Taxes, permit fees, or other fees assessed by Governmental organizations
- Positive Material Identification (PMI) requirements and Third Party Certification.
- Any and all permits or special clearances required by any government agency. This includes air, water, or discharge pollution permits as well as Local building permits, construction permits, etc.
- Any local Codes and Standards not expressly included in the contract



#### APPENDIX F – SPECIMEN INSURANCE POLICY

7-26-01 4:37PM:ROLLS ROYCE  
7-26-01 4:20PM

1740 393 8179 # 2  
MARSH USA INC.

PROVIDER		CERTIFICATE OF INSURANCE		CERTIFICATE NUMBER	
PAMELA THOMAS (312) 627-6282 MARSH USA INC. 500 WEST MONROE STREET CHICAGO, VA 80661		THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER OTHER THAN THOSE PROVIDED IN THE POLICY. THIS CERTIFICATE DOES NOT AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICES DESCRIBED HEREIN.		CHI-000677488-00	
301249-005-GLAWC-89-00		COMPANIES AFFORDING COVERAGE			
INSURED		COMPANY			
Rolls-Royce Energy Systems Attn: Joe Long 14850 Conference Center Dr Chantilly, VA 20151		A ROYAL & SUN ALLIANCE			
		B FEDERAL INSURANCE CO			
		C			
		D			
THIS IS TO CERTIFY THAT POLICES OF INSURANCE DESCRIBED HEREIN HAVE BEEN ISSUED TO THE INSURED NAMED HEREIN FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THE CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, CONDITIONS AND EXCLUSIONS OF SUCH POLICES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.					
CO LTR	TYPE OF INSURANCE	POLICY NUMBER	POLICY EFFECTIVE DATE (MM/DD/YY)	POLICY EXPIRATION DATE (MM/DD/YY)	LIMITS
A	GENERAL LIABILITY	RIX 700711000Y	06/01/01	05/01/02	GENERAL AGGREGATE \$ 5,000,000 PRODUCTS - COMP/OP AGG \$ 5,000,000 PERSONAL & ADVINJURY \$ 5,000,000 EACH OCCURRENCE \$ 5,000,000 FIRE DAMAGE (Any one fire) \$ 50,000 MED EXP (Any one person) \$ 5,000
	<input checked="" type="checkbox"/> COMMERCIAL GENERAL LIABILITY				
	<input checked="" type="checkbox"/> CLAIMS MADE <input type="checkbox"/> OCCUR				
	<input type="checkbox"/> OWNERS & CONTRACTOR'S PROT				
B	AUTOMOBILE LIABILITY	7324 57 07 (AOS)	06/01/01	05/01/02	COMBINED SINGLE LIMIT \$ 2,000,000
B	<input checked="" type="checkbox"/> ANY AUTO	7324 57 11 (TX)	05/01/01	05/01/02	
B	<input type="checkbox"/> ALL OWNED AUTOS	73-24-57-10 (VA)	06/01/01	05/01/02	
	<input type="checkbox"/> SCHEDULED AUTOS				
	<input type="checkbox"/> HIRED AUTOS				
	<input type="checkbox"/> NON-OWNED AUTOS				
	<input type="checkbox"/> \$250 DEDUCTIBLE FOR COMP & COLLISION				
	GARAGE LIABILITY				
	<input type="checkbox"/> ANY AUTO				
	EXCESS LIABILITY				
	<input type="checkbox"/> UMBRELLA FORM				
	<input type="checkbox"/> OTHER THAN UMBRELLA FORM				
B	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY	WC 7164-63-28	05/01/01	05/01/02	WC STATUTORY LIMITS \$ 2,000,000 EL EACH ACCIDENT \$ 2,000,000 EL DISEASE-POLICY LIMIT \$ 2,000,000 EL DISEASE-EACH EMPLOYEE \$ 2,000,000
	THE PROPRIETOR/ PARTNER/EXECUTIVE OFFICERS ARE	<input checked="" type="checkbox"/> INCL. <input type="checkbox"/> EXCL.			
	OTHER				
DESCRIPTION OF OPERATIONS/LOCATIONS/VEHICLES/SPECIAL ITEMS (LIMITS MAY BE SUBJECT TO DEDUCTIBLES OR RETENTIONS)					
FOR EVIDENCE ONLY					
SHOULD ANY OF THE POLICES DESCRIBED HEREIN BE CANCELLED BEFORE THE EXPIRATION DATE THERE OF, THE INSURER AFFORDING COVERAGE WILL ENDEAVOR TO MAIL 30 DAYS WRITTEN NOTICE TO THE CERTIFICATE HOLDER NAMED HEREIN, BUT FAILURE TO MAIL SUCH NOTICE SHALL IMPOSE NO OBLIGATION OR LIABILITY OF ANY KIND UPON THE INSURER AFFORDING COVERAGE, ITS AGENTS OR REPRESENTATIVES.					
MARSH USA INC. By: Eliza M. Lynch <i>Eliza M. Lynch</i>					
DATE: 7/26/01					



## **APPENDIX G – CANCELLATION SCHEDULE**

If at any time after the Contract becomes effective, the Contract or a part thereof is cancelled by Customer, or if RR is entitled to terminate the Contract in accordance with the termination provisions set out therein, RR shall be entitled to be paid in accordance with the following cancellation schedule.

Month	Cancellation Date	Cancellation Amount		Cumulative Amount
		Unit 1	Unit 2	Unit 1 & 2
Contract	June 2010	\$3,500,000	\$2,300,000	\$5,800,000.00
1	July 2010	\$7,000,000	\$4,600,000	\$11,600,000.00
2	August 2010	\$15,400,000	\$6,900,000	\$22,300,000.00
3	September 2010	\$17,600,000	\$15,400,000	\$33,000,000.00
4	October 2010	\$19,800,000	\$17,600,000	\$37,400,000.00
5	November 2010	\$22,000,000	\$19,800,000	\$41,800,000.00
6	December 2010	\$22,000,000	\$22,000,000	\$44,000,000.00

**Note 1** - Upon notification of each Unit ready to ship Ex-works the cancellation charge for that Unit will be 100% of the value allocated to that Unit. If the Contract is cancelled prior to readiness to Ship, title to the Equipment shall be retained by RR upon the payment of the cancellation charges. If the Contract is cancelled at or after Readiness to Ship, title to the Units shall transfer upon the earlier to occur of (i) receipt by RR of full Contract Price with respect to such Equipment as might be due under the Contract, and (ii) delivery of Equipment Ex-works pending credit support of the outstanding balance payable to RR.



## ***APPENDIX H – SITE PERFORMANCE TEST PROTOCOL***

Site performance test protocol STP No. G.7.W is provided in attachment section of this contract.



## ***ATTACHMENTS***

- Supplier Document Requirement List
- Inspection and Test Plan
- Typical General Arrangement
- GER0070
- GER0144
- STP No. G.7.W (Site Performance Test Protocol)

# Rolls-Royce Standard Document Requirements List (SDRL)

## TRENT 60 (Phase IV) WLE Dual Fuel On-Shore Power Generation

Customer P1797

Project Number

P.O. Date TBD

Ship Date TBD

Project Trent Phase IV Power Generation Packa

Ex-Works Aug-10

Revision A

Revision Date April, 2010

Category Letter	Sequence Number	Document / Drawing Number Reference	Customer Reference Number	Description	Major Doc.	Certified Final	As Built	As Installed
<b>A CONTROL DOCUMENTS</b>								
	A100	GEDXXXXXXXX		Supplier Document Requirements List (SDRL)		2	N/A	As Required
<b>B INTERFACE AND ARRANGEMENT</b>								
	B100	<u>GENERAL ARRANGEMENT DRAWINGS</u>						
	B107			General Arrangement Drawing - Trent Power Generation - includes GT package, AC Generator, Water Injection, Liquid Fuel Forwarding Skid, Fire and Gas and Mineral Lube Oil		6	TBD	As Required
	B300	<u>FOUNDATION AND LOADING DRAWINGS</u>						
	B307			Foundation and loading plan - Trent Power Generation - includes GT package, AC Generator, Water Injection, Fire and Gas, Mineral Lube Oil		6	TBD	As Required
	B400	<u>SHIPPING DRAWING</u>						
	B407			Shipping Arrangement Drawing		6	TBD	As Required
<b>C DESIGN OPERATIONAL DATA</b>								
	C100	<u>SYSTEM DIAGRAMS (P&amp;ID's)</u>						
	C101			Engine Ignition and Instrumentation Diagram - WLE Dual Fuel		7	TBD	As Required
	C104			AC Generator Instrumentation Diagram		7	TBD	As Required
	C107			GT Oil System Diagram - WLE		7	TBD	As Required
	C110			IGV / BOV Control Diagram - WLE		7	TBD	As Required
	C113			Water Flush System Diagram		7	TBD	As Required
	C116			AC Generator Lube Oil Diagram		7	TBD	As Required
	C119			Instrument Air Diagram - WLE		7	TBD	As Required
	C122			Combustion Air Diagram - WLE		7	TBD	As Required
	C125			Enclosure Negative Ventilation Diagram		7	TBD	As Required
	C128			Gas Fuel System Diagram - WLE / DUAL FUEL		7	TBD	As Required
	C131			Liquid Fuel System Diagram		7	TBD	As Required

Category Letter	Sequence Number	Document / Drawing Number Reference	Customer Reference Number	Description	Major Doc.	Certified Final	As Built	As Installed
	C134			P30 Purge Air System Diagram - WLE		7	TBD	As Required
	C137			Water Injection System Diagram - WLE L		7	TBD	As Required
	C140			Fire and Gas GT Diagram		7	TBD	As Required
	C143			Water Wash Diagram		7	TBD	As Required
	C150			Fire and Gas AC Generator Diagram		7	TBD	As Required
	C151			AC Generator Ventilation Diagram		7	TBD	
D	DATA SHEETS							
D200				UTILITY CONSUMPTION LIST				
	D210			Utility Consumption List		10	TBD	As Required
E	ELECTRICAL DRAWINGS							
E200				SINGLE LINE DIAGRAMS				
	E222			High Voltage Single Line Diagram		10	TBD	As Required
E100				ELECTRICAL CONNECTION				
	E190			Electrical Interconnect Drawing		6	TBD	As Required
E400				HAZARDOUS AREA DRAWING				
	E410			Hazardous Area Classification Drawing		6	TBD	As Required
F	CONTROLS							
F100				UNIT CONTROL PANEL (UCP)				
	F110			Unit Control Panel Logic Flow Diagram		10	TBD	As Required
	F120			Unit Control Panel Schematic		10	TBD	As Required
	F140			Unit Control Panel Outline Drawing		10	TBD	As Required
	F150			Topology Diagrams		6	TBD	As Required
	F160			Unit Control Panel Assembly Drawing		10	TBD	As Required
	F170			Alarm and Trip Matrix		12	TBD	As Required
F300				FIRE & GAS SYSTEM CONTROL PANEL				
	F340			F&G Panel Cause and Effect Chart		17	54	As Required
G	CALCULATIONS and PERFORMANCE							
G100				PERFORMANCE DATA				



Category Letter	Sequence Number	Document / Drawing Number Reference	Customer Reference Number	Description	Major Doc.	Certified Final	As Built	As Installed
	G110			Gas Turbine Performance Data		8	N/A	N/A
	G120			Generator Performance Data		8	N/A	N/A
<b>H PROCEDURES and REPORTS</b>								
H100				<u>PROCEDURES</u>				
	H110			Supplier Document Requirements List (SDRL) Master Listing		4	N/A	N/A
	H120			Standard Diagram Symbols		4	N/A	N/A
	H130			Operation and Maintenance Manual Specification		4	N/A	N/A
	H140			Paint Procedures (GER 0056 / GEM 0018 w/ SSDS)		4	N/A	N/A
H200				<u>TEST PROCEDURES</u>				
	H210			Gas Generator Pass-Off Procedure		6 Weeks Before Test	N/A	N/A
	H250			Recommended Site Performance Pass-off Test Procedure		6 Weeks Before Test	N/A	N/A
H300				<u>TEST REPORTS</u>				
	H310			Gas Turbine Pass-Off Report		4 Weeks After Test	N/A	N/A
	H340			Electrical Generator Mechanical Test Report		4 Weeks After Test	N/A	N/A
	H350			Site Performance Pass-off Test Report		4 Weeks After Test	N/A	N/A
<b>J QUALITY DOCUMENTATION</b>								
J200				<u>DOCUMENT DOSSIER</u>				
	J210			Document Dossier		N/A	8 Weeks After Ship	N/A
<b>K SPARE PARTS LISTS</b>								
K100				<u>START-UP AND COMMISSIONING</u>				
	K110			Start-up and Commissioning Spare Parts List (Unpriced)		4 Weeks Before Shipment	AS REQUIRED	N/A
K200				<u>SCHEDULED MAINTENANCE SPARE PARTS LIST</u>				
	K210			Scheduled Maintenance Spare Parts List (Unpriced)		N/A	AS REQUIRED	N/A
K300				<u>STRATEGIC / INSURANCE SPARE PARTS LIST</u>				
	K310			Strategic / Insurance Spare Parts List (Unpriced)		N/A	AS REQUIRED	N/A
<b>L OPERATIONS MANUALS</b>								
L100				<u>GAS TURBINE MAINTENANCE AND PARTS MANUALS</u>				
	L110			Gas Turbine Maintenance and Parts Manuals		8 Weeks After Shipment	N/A	N/A

Category Letter	Sequence Number	Document / Drawing Number Reference	Customer Reference Number	Description	Major Doc.	Certified Final	As Built	As Installed
L200 <u>RRESI PACKAGE MAINTENANCE MANUALS</u>								
	L210			RRESI Package Maintenance Manuals		8 Weeks After Shipment	N/A	N/A
L300 <u>RRESI CONTROLS OPERATIONS AND INSTRUCTION MANUALS</u>								
	L310			RRESI Controls Operations and Instruction Manuals		8 Weeks After Shipment	N/A	N/A
L400 <u>RRESI PACKAGING INSTALLATION MANUAL</u>								
	L410			RRESI Packaging Installation Manual		8 Weeks After Shipment	N/A	N/A
L500 <u>RRESI PACKAGE OPERATING GUIDELINES MANUAL</u>								
	L510			RRESI Package Operating Guidelines Manual		8 Weeks After Shipment	N/A	N/A
L600 <u>DRIVEN EQUIPMENT MAINTENANCE MANUAL</u>								
	L610			Driven Equipment Maintenance Manual		8 Weeks After Shipment	N/A	N/A

NOTES:

- 1.) Not used
- 2.) Not Used
- 3.) "Certified" documents convey the official Rolls-Royce engineering design.
- 4.) "As-Built" and "As-Installed" documents will not be provided unless a design change that affects form, fit, or function has occurred during the manufacturing/assembly or installation & commissioning.
- 5.) Only submitted if changes from the contract or if additional data has become available.
- 6.) Not used
- 7.) The submission dates shown within the Supplier Document Requirements List (SDRL) are based upon the first down payment received by RR, which starts the clock on the delivery and submission dates. If the VCM does not happen within this time frame, these dates may move out week per week until the VCM takes place.
- 8.) Not used
- 9.) This Document contains technical data whose export is restricted by the Export Administration Act of 1979, as amended (Title 50, U.S.C., App 2401, Et Seq) and is controlled by the Export Administration Regulations (15 CFR parts 730-774) under ECCN EAR99. Diversions contrary to US export law is prohibited.
- 10.) Not used



# Rolls-Royce

## Rolls-Royce Energy Systems Inc.

### Trent WLE Power Generation Inspection and Test Plan

Project: 2 X Trent 60 WLE, DF

Issue: Certified

Issue Date: 28 April 2010

#### EXPORT-CONTROLLED DOCUMENT

This document contains technical data whose export is restricted by the Export Administration Act of 1979, as amended (Title 50, U.S.C., App 2401, Et Seq.) and is controlled by the Export Administration Regulations (15 CFR parts 730-774) under ECCN EAR99. Diversion contrary to US export law is prohibited.

# Table of Contents

REVISION INDEX.....	3
DEFINITIONS .....	3
GENERAL .....	5
BASEPLATE.....	6
FUEL MODULE .....	7
FUEL IN-SKID INTERCONNECT SYSTEM.....	8
GT LUBE OIL CONSOLE .....	9
GT LUBE OIL SYSTEM .....	10
UNIT CONTROL PANEL (UCP) .....	11
AIR INTAKE FILTER SYSTEM .....	12
ACOUSTIC ENCLOSURE/INTAKE/EXHAUST/SILENCERS/ PLENUMS, STRUCTURES AND VENT SYSTEM.....	13
TRENT GAS TURBINE.....	14
CO <sub>2</sub> FIRE DETECTION AND SUPPRESSION SYSTEM.....	15
COUPLING.....	16
AIR COOLED GENERATOR .....	17
GENERATOR CONTROL PANEL .....	23
MINERAL LUBE OIL CONSOLE .....	22
WATER INJECTION SYSTEM .....	25
LIQUID FUEL FORWARDING SKID.....	26
TRENT TESTING, PACKAGING, AND SHIPPING.....	27
ABBREVIATIONS.....	28

<b>Responsible Party</b> 1 = Rolls-Royce Energy Systems Inc. 2 = Supplier 3 = Customer or Customer Agency 4 = Third Party		A = Approval Required D = Document Required O = Observation Point (Requires 14 calendar days advanced notification) R = Review Required W = Witness Point (Requires 14 calendar days advanced notification)	
Project: 2XTrent 60 WLE		Doc.: GEDXXXXXX	Rev.: 000

# Revision Index

Rolls-Royce Quality Rep.	Date	Description of Change	Rev.
P. Michaels	28 Apr 2010	Initial issue as Certified	000

## Definitions

Abbreviation	Term	Definition
A	Approval	An approved document is required in order to proceed.
D	Document	A document is required to be produced and maintained in the manufacturing records. Note: A Certificate of Compliance (C of C) is provided when the actual document contains proprietary information.
O	Observation	An activity where the purchaser is notified of the timing of the activity and the activity is performed as scheduled if the purchaser or the purchaser's representative is not present. Note: Components purchased for general inventory (schedule agreements) are not available for OBSERVATION at the supplier's facility.
R	Review	A documentation, activity, or quality characteristic review is required. In the event that the purchaser does not review an activity, the activity may not be repeated. A document review can take place subsequent to the activity being completed.
W	Witness	An activity where the purchaser is notified of the timing of the activity and a hold is placed on the activity until the purchaser or the purchaser's representative is in attendance unless the purchaser has granted a written waiver. Rolls-Royce reserves the right to proceed with the activity 5 working days after the specified date if there is a substantial financial impact to the business. Note: Components purchased for general inventory (schedule agreements) are not available for WITNESS at the supplier's facility.

### Responsible Party

1 = Rolls-Royce Energy Systems Inc.  
2 = Supplier  
3 = Customer or Customer Agency  
4 = Third Party

A = Approval Required  
D = Document Required  
O = Observation Point (Requires 14 calendar days advanced notification)  
R = Review Required  
W = Witness Point (Requires 14 calendar days advanced notification)

Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

Notification: The customer and any appointed representatives will be issued a notification in advance of inspection activities designated as Observation or Witness points. The standard for this notification is 14 calendar days and may be adjusted to meet project specific requirements. A confirmation will be issued 7 calendar days (5 business days) in advance confirming the actual activity date.

Recommendations: It is recommended that the designated inspector make contact with RRESI and sub-supplier representatives to agree on final date and time as necessary. For inspectors traveling by air, it is recommended that airline tickets be purchased with open ended departure and arrival dates.

Schedule: A project inspection schedule will be published after customer approval of the Inspection and Test Plan. This schedule, which will be issued with the Project Manager’s Monthly Report, should be used for long range planning.

Quality Data Dossier: A Quality Data Dossier is issued within 4 weeks after the equipment ex-works date. The dossier consists of a copy of the documentation on one CD-ROM or CD-ROM set. Documentation will be compiled and indexed in accordance with Rolls-Royce’ standards.

Notes:

Throughout this document, the Supplier in Column 2 of the Responsible Party may refer to a party external to Rolls-Royce or to another group within Rolls-Royce.

Rolls-Royce and sub-supplier procedures are available for customer review at the manufacturing facility upon request.

<u>Responsible Party</u> 1 = Rolls-Royce Energy Systems Inc. 2 = Supplier 3 = Customer or Customer Agency 4 = Third Party		A = Approval Required D = Document Required O = Observation Point (Requires 14 calendar days advanced notification) R = Review Required W = Witness Point (Requires 14 calendar days advanced notification)	
Project: 2XTrent 60 WLE		Doc.: GEDXXXXXX	Rev.: 000

# General

				RESPONSIBLE PARTY				REMARKS
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	
1	Approval of contract	LOP P.5.D	Contract Specifications	A				
2	Approval of Inspection and Test Plan (ITP)	LOP P.8.6	Contract Specifications	A				
3	Approval of mechanical and/or performance test procedures	Purchase Order	Contract Specifications	A				

<u>Responsible Party</u> 1 = Rolls-Royce Energy Systems Inc. 2 = Supplier 3 = Customer or Customer Agency 4 = Third Party		A = Approval Required D = Document Required O = Observation Point (Requires 14 calendar days advanced notification) R = Review Required W = Witness Point (Requires 14 calendar days advanced notification)
Project: 2XTrent 60 WLE		Doc.: GEDXXXXXX Rev.: 000

# Baseplate

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Baseplate structural steel Material Certification	Material Certificates	EN 10204 3.1	R	D			
2	Review of : <ul style="list-style-type: none"> <li>Weld procedures</li> <li>PQRs</li> <li>Welder qualifications</li> <li>NDE procedures</li> </ul>	AWS D1.1	AWS D1.1	R	D			
3	Visual in process checks during welding - dimensional checks, flatness, completed welds	AWS D1.1 & Drawing	AWS D1.1	R	D			
4	NDE <ul style="list-style-type: none"> <li>100% MPI and UT of full penetration main structural welds</li> <li>100% MPI of all lifting points</li> </ul>	AWS D1.1	AWS D1.1	R	D			
5	100% Visual Weld Inspection	AWS D1.1 & Drawing	AWS D1.1	R	D			
6	<ul style="list-style-type: none"> <li>Full dimensional report on final fabrication</li> <li>Dimensional survey after machining</li> </ul>	Drawing	Drawing Tolerances	R	D			
7	Verify paint is applied in accordance with the standard procedure	WI F.2.2.E & GER 0056	GER 0056	R	D			
8	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Tagging</li> <li>Nameplates</li> </ul>	GER 0056 & GQP F.2.5	Drawing Tolerances & GQP F.2.5	O	D			
9	Documentation review	GQP F.2.5	Drawing, procedure, and specification requirements	O	D			
10	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000



# Fuel Module

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Piping: receiving inspection to ensure only certified material is accepted and released to warehouse	WI F.2.4.A	Certificate of Conformance & EN 10204 3.1	R	D			
2	Pipe fabrication <ul style="list-style-type: none"> <li>100% visual examination of completed welds and dimensional spot checks</li> </ul>	GEM 0028 & GEM 0031	GEM 0028 & GEM 0031	R	D			
3	NDE: <ul style="list-style-type: none"> <li>100% Radiographic testing of all butt welds</li> <li>100% dye penetrant inspection of branch, socket, and seal welds</li> </ul>	GEM 0050, GEM 0129	ANSI B31.3 & Normal Fluid Service	R	D			
4	<ul style="list-style-type: none"> <li>Hydrotest and visual examination of fuel piping</li> <li>All pipe spools to be tested to procedure and drawing requirements</li> </ul>	GEM 0030 & GEM 0028	Zero Leaks & GEM 0050	R	D			
5	Record heat numbers of pipe spool components and consumables on pipe spool drawing	Drawing	Recorded on Drawing	R	D			
6	Instrumentation line leak test	GEM 0042	Zero Leaks	R	D			
7	<ul style="list-style-type: none"> <li>Wiring continuity test</li> <li>Insulation resistance test</li> </ul>	GEM 0047	GEM 0047	R	D			
8	Final inspection <ul style="list-style-type: none"> <li>Dimensional inspection</li> <li>Tagging</li> <li>Nameplates</li> </ul>	GQP F.2.5	Drawing Tolerances & GQP F.2.5	R	D			
9	Documentation review	GQP F.2.5	Purchase Order	R	D			
10	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

NOTE: The standard fuel module is purchased on schedule agreements from the supplier and installed on the turbine skid by Rolls-Royce. Therefore, Witness or Observation at specific process steps may not be possible.

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Project: 2XTrent 60 WLE	Doc.: GEDXXXXXX Rev.: 000

# Fuel In-skid Interconnect System

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Piping: receiving inspection to ensure only certified material is accepted and released to warehouse	WI F.2.4.A	Certificate of Conformance & EN 10204 3.1 for pressure parts & type 2.2 for filler metal	R	D			
1.1	Review of : <ul style="list-style-type: none"> <li>Weld procedures</li> <li>PQRs</li> <li>Welder qualifications</li> <li>NDE procedures</li> </ul>	AWS D1.1	AWS D1.1	R	D			These documents will be available for review at the manufacturing facility.
2	Pipe fabrication <ul style="list-style-type: none"> <li>100% visual examination of completed welds and dimensional spot checks</li> </ul>	GEM 0028 & GEM 0031	GEM 0028 & GEM 0031	R, D				
3	NDE: <ul style="list-style-type: none"> <li>100% Radiographic testing of all butt welds</li> <li>100% dye penetrant inspection of branch, socket, and seal welds</li> </ul>	GEM 0050	ANSI B31.3 & Normal Fluid Service	R, D	D			
4	<ul style="list-style-type: none"> <li>Hydrotest and visual examination of fuel piping</li> <li>All pipe spools to be tested to procedure and drawing requirements</li> </ul>	GEM 0030 & GEM 0028	Zero Leaks & GEM 0050	R, D				
5	Record heat numbers of pipe spool components and consumables on pipe spool drawing	Drawing	Recorded on Drawing	R, D				
6	Instrumentation line leak test	GEM 0042	Zero Leaks	R, D				
7	<ul style="list-style-type: none"> <li>Wiring continuity test</li> <li>Insulation resistance test</li> </ul>	GEM 0047	GEM 0047	R, D				
8	Final inspection <ul style="list-style-type: none"> <li>Dimensional inspection</li> <li>Tagging</li> <li>Nameplates</li> </ul>	GQP F.2.5	Drawing Tolerances & GQP F.2.5	R				Part of final package inspection.

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# GT Lube Oil Console

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Certificates of compliance for all wetted parts of component and/or sub-assemblies <ul style="list-style-type: none"> <li>Vessels</li> <li>Pipe</li> <li>Pipe fittings, including flanges, valves, tubing, instruments, and welding consumables</li> </ul>	Supplier Procedure	Certificate of Compliance & EN 10204 3.1	R	D			
2	Pipe fabrication <ul style="list-style-type: none"> <li>100% visual examination of completed welds and dimensional spot checks</li> </ul>	Supplier Procedure	Drawing Tolerances and Data Sheets	R	D			
3	NDE <ul style="list-style-type: none"> <li>5% radiographic testing of lube oil piping butt welds</li> <li>100% dye penetrant inspection of branch, socket, and seal welds</li> </ul>	Supplier Procedure	Drawing Tolerances and Data Sheets	R	D			
4	<ul style="list-style-type: none"> <li>Hydrotest and visual examination of lube oil piping</li> <li>All pipe spools to be tested to procedure and drawing requirements</li> </ul>	Supplier Procedure	Drawing Tolerances and Data Sheets	R	D			Hydro test duration must be at least 30 minutes and test pressure at least 1.5 x design pressure.
5	Record heat numbers of pipe spool components and consumables.	Supplier Procedure	Drawing Tolerances and Data Sheets	R	D			
6	Visual inspection of pump	Supplier Procedure	Drawing Tolerances and Data Sheets	R	D			
8	Visual inspection of electric motors	Supplier Procedure	Drawing Tolerances and Data Sheets	R	D			
7	<ul style="list-style-type: none"> <li>Insulation resistance test</li> <li>Wiring continuity test</li> </ul>	Supplier Procedure	Contract Specifications	R	D			
8	Instrumentation line leak test	Supplier Procedure	Zero Leaks	R	D			
9	Flushing of complete console	GEM 0064	GEM 0064 & API 614	R	D			
10	Functional, electrical and leak test	Supplier Procedure	Specification	R	D			
11	Surface preparation and painting: verify surfaces to be coated have been prepared in accordance with the approved procedure	Approved Procedure	Approved Procedure	R	D			
12	Verify paint is applied in accordance with the standard procedure	WI F.2.2.E & GER 0056	GER 0056	R	D			
13	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Tagging</li> <li>Nameplates</li> </ul>	R-R approved Paint Procedure & GQP F.2.5	Drawing Requirements & GQP F.2.5	O	D			
14	Weighing of unit	GEM 0013	Weight cert.	R	D			
15	Documentation review	GQP F.2.5	Purchase Order	O	D			
16	Shipping release (RRESI approval required before supplier ships)	LOP F.2.3-1	LOP F.2.3-1	A	D			

NOTE: The standard GT lube oil console is purchased on schedule agreements from the supplier and installed on the turbine skid by Rolls-Royce Energy Systems Inc. Therefore, Witness or Observation at specific process steps may not be possible.

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Project: 2XTrent 60 WLE	Doc.: GEDXXXXXX      Rev.: 000

# GT Lube Oil System

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Certificates of compliance for all wetted parts of component and/or sub-assemblies <ul style="list-style-type: none"> <li>Vessels</li> <li>Pipe</li> <li>Pipe fittings, including flanges, valves, tubing, instruments, and welding consumables</li> </ul>	WI F.2.4.A	Certificate of Compliance & EN 10204 2.1	R	D			
2	Pipe fabrication <ul style="list-style-type: none"> <li>100% visual examination of completed welds and dimensional spot checks</li> </ul>	GEM 0028 & GEM 0031	GEM 0028 & GEM 0031	R, D				
3	NDE <ul style="list-style-type: none"> <li>5% radiographic testing of lube oil piping butt welds</li> <li>100% dye penetrant inspection of branch, socket, and seal welds</li> </ul>	GEM 0050 & GEM0129	ANSI B31.3	R	D			
4	<ul style="list-style-type: none"> <li>Hydrotest and visual examination of lube oil piping</li> <li>All pipe spools to be tested to procedure and drawing requirements</li> </ul>	GEM 0030 & GEM 0028	Zero Leaks & GEM 0059	R, D				
5	Record heat numbers of pipe spool components and consumables on pipe spool drawing	Drawing	Recorded on Drawing	R, D				
6	Visual inspection of reservoir cleanliness	WI F.2.4.A	Cleanliness	R, D				
7	<ul style="list-style-type: none"> <li>Insulation resistance test</li> <li>Wiring continuity test</li> </ul>	GEM 0047	GEM 0047	R, D				
8	Flushing of piping system	GEM 0064	GEM 0064	R, D				
9	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Dimensional inspection - reservoir and connection points</li> <li>Cleaning</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Standard Paint Procedure & GQP F.2.5	Drawing Tolerances & Contract Compliance	R, D				Part of final package inspection.

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Unit Control Panel (UCP)

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Dimensional inspection of entry and connection locations	Supplier Procedure	Approved Drawing	R	D			
2	Grounding facilities inspection	Supplier Procedure	Approved Drawing	R	D			
3	Continuity test	Supplier Procedure	Supplier Procedure	R	D			
4	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	GQP F.2.5	Specification	R	D			
5	Documentation review	GQP F.2.5	Purchase Order	R	D			
6	Shipping release (RRESI approval required for supplier to ship)	WI F.2.6.A	WI F.2.6.A	W, A	D			
7	Simulation test/factory acceptance test (FAT)	Approved Procedure	Test Report	D				Performed at R-R
8	Final inspection <ul style="list-style-type: none"> <li>Paint to manufacturers standard</li> <li>Where specified, protective coating and preservation</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Standard Paint Procedure & GQP F.2.5	Drawing Tolerances & Contract Compliance	R, D				
9	RRESI internal shipping release	WI F.2.6.A	WI F.2.6.A	A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Air Intake Filter System

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Review procedures (weld, NDT, paint, shipping and storage)	Purchase Order	Contract Specification	R	R			
2	Visual weld inspection of fabricated components, including platforms, ladders and handrails prior to painting and/or protective coating	AWS D1.1	AWS D1.1	R	D			
3	Dimensional inspection of final components	Approved Procedures	Drawing	A	D			
4	Dimensional inspection and trial fit up of completed assembly as required	Approved Procedures	Drawing	A	D			
5	<ul style="list-style-type: none"> <li>Insulation resistance test</li> <li>Wiring continuity test</li> </ul>	Approved Procedures	Approved Procedures	A	D			
6	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional and nameplate inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Standard Paint Procedure & GQP F.2.5	Drawing Tolerances & GQP F.2.5	O	D	O		
7	Documentation review	GQP F.2.5	Purchase Order	A	D			
8	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Acoustic Enclosure/Intake/Exhaust/Silencers/ Plenums, Structures and Vent System

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Review procedures (weld, NDT, paint, shipping and storage)	Purchase Order	Contract Specifications	R	D			
2	Visual weld inspection of fabricated components prior to painting and/or protective coating	AWS D1.1	AWS D1.1	R	D			
3	Dimensional inspection of final components	Approved Procedure	Drawing Tolerances	R	D			
4	Dimensional inspection and trial fit up of completed assembly as required	Approved Procedure	Drawing Tolerances	R	D			
5	Dimensional inspection report for interface with air inlet filter and base	Approved Procedure	Drawing Tolerances	R	D			
6	Surface preparation and painting: verify surfaces to be coated have been prepared in accordance with the approved procedure	Approved Procedure	Approved Procedure	R	D			
7	Verify paint is applied in accordance with the approved procedure	Approved Procedure	Approved Procedure	A	D			
8	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional and nameplate inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Approved Paint Procedure & GQP F.2.5	Drawing Tolerances & GQP F.2.5	O	D			Direct ship items
9	Documentation review	GQP F.2.5	GQP F.2.5	O	D			
10	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Trent Gas Turbine

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Submit Test Procedure of Industrial Trent Gas Turbine	R-R procedure	Specification	R	D			
2	Mechanical and performance testing at Roll-Royce Canada in Montreal	GTES 10760	Specification	R	D			
3	Performance test per GTES 10760 at Rolls-Royce Canada in Montreal	GTES 10760	GTES 10760	W	D	O		
4	Chip and Boroscope Inspection	R-R procedure	Specification	W, R	D			
5	Final Quality Plan document review	R-R procedure	Specification	O	D			
6	Shipping release (RRESI approval required before turbine ships to RRESI or customer site)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000



# CO<sub>2</sub> Fire Detection and Suppression System

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Pressure containing parts material certifications	Purchase Order	Material Specification	R	D			
2	Visual and dimensional inspection of skid	Approved Procedure	Approved Drawing & Cleanliness	R	D			
3	<ul style="list-style-type: none"> <li>Wiring continuity test</li> <li>Insulation resistance test</li> </ul>	Approved Procedure	Approved Procedure	R, D	D			
4	Component checks and controller simulation testing	Approved Procedure	Purchase Order	O	D			Test of system control panel & system components.
5	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional and nameplate inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Standard Paint Procedure & GQP F.2.5	Drawing Tolerances & GQP F.2.5	O	D			
6	Documentation review	GQP F.2.5	Purchase Order	O	D			
7	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

Note: 1.) An assembled system operational test is performed in the field during commissioning.  
2.) CO2 bottles are not included.

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Project: 2XTrent 60 WLE	Doc.: GEDXXXXXX      Rev.: 000

# Coupling

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Torque transmitting component material certification	Supplier Procedure	Material Specification	R	D			
2	Torque transmitting component nondestructive test	Supplier Procedure	Supplier Procedure	R	D			
3	Assembly final dimensional inspection	Supplier Procedure	Engineering Drawing	R	D			
4	Hub taper and contact inspection	Supplier Procedure	Standard Procedure	R	D			
5	Assembly dynamic balance and match marking	API-671	Supplier Procedure	R	D			
6	Final inspection	GQP F.2.5	Material Specification & Purchase Order	O	D			
7	Documentation review	GQP F.2.5	Purchase Order	R	D			
8	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Air Cooled Generator

				RESPONSIBLE PARTY				
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
Forged Shaft								
1	Chemical analysis	Heat & Product Analysis	Specification	R	D			
2	Forging and quality heat treatment	Supplier Procedure	Specification	R	D			
3	<ul style="list-style-type: none"><li>Tensile test</li><li>Impact test</li><li>Ultrasonic test</li><li>Identification operations</li></ul>	Supplier Procedure	Specification	R	D			
4	Final machining	Drawing	Drawing	R	D			
5	Shaft dimensional and geometrical measurements	Drawing	Drawing	R	D			
6	Marking and visual inspection	Supplier Procedure	Specification	R	D			
7	Certificate of conformity	Purchase Order	Specification	R	D			
Rotor Magnetic Sheets								
8	<ul style="list-style-type: none"><li>Magnetic test</li><li>Identification operations</li></ul>	Supplier Procedure	Specification	R	D			
9	Dimensional inspection	Supplier Procedure	Specification	R	D			
10	Certificate of conformity	Purchase Order	Specification	R	D			
Rotor								
11	<ul style="list-style-type: none"><li>Electrical test</li><li>Identification operations</li></ul>	Supplier Procedure	Specification	R	D			
12	Dimensional inspection	Supplier Procedure	Specification	R	D			
13	Certificate of conformity	Purchase Order	Specification	R	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

				RESPONSIBLE PARTY								
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS				
Welded Frame												
14	Review and approve weld procedures and welder qualifications (PQR, WPS and WPQ)	Supplier Procedure	Specification	A	D							
15	Review and approve NDT procedure and operator qualification	Supplier Procedure	Specification	A	D							
16	Certification for materials for frame housing, lifting lugs and filler metals	Specification	Acceptance Report	R	D							
17	<ul style="list-style-type: none"> <li>Weld inspection: visual and dimensional</li> <li>100% NDT of lifting lugs</li> </ul>	Supplier Procedure	Drawing	R	D							
18	Preparation for painting: shot blasting, cleanliness before painting	Supplier Procedure	Reports	R	D							
19	Paint inspection: paint thickness and adhesion	Supplier Procedure	Reports	R	D							
20	Final inspection: dimensional, visual and marking	Drawing	Drawing	R	D							
21	Certificate of conformity	Purchase Order	Specification	R	D							
Copper Stator												
22	<ul style="list-style-type: none"> <li>Identification operations</li> <li>Electrical test</li> </ul>	Supplier Procedure	Specification	R	D							
23	Dimensional inspection	Supplier Procedure	Specification	R	D							
24	Certificate of conformity	Purchase Order	Specification	R	D							
Bearings												
25	Material traceability: shells - white metal chemical composition	EN 10204 3.1	Specification	R	D							
26	<ul style="list-style-type: none"> <li>Ultrasonic test</li> <li>Dimensional inspection</li> <li>Geometric inspection</li> <li>Visual inspection</li> </ul>	ISO 4386 & EN 10204 3.1	Specification	R	D							
27	Identification of parts	Supplier Procedure	Specification	R	D							
28	Certificate of conformity	Purchase Order	Specification	R	D							
<table border="1" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <b>Responsible Party</b>            1 = Rolls-Royce Energy Systems Inc.            2 = Supplier            3 = Customer or Customer Agency            4 = Third Party         </td> <td style="width: 50%; vertical-align: top;">           A = Approval Required            D = Document Required            O = Observation Point (Requires 14 calendar days advanced notification)            R = Review Required            W = Witness Point (Requires 14 calendar days advanced notification)         </td> </tr> <tr> <td colspan="2">           Project: <b>2XTrent 60 WLE</b> </td> </tr> </table>									<b>Responsible Party</b> 1 = Rolls-Royce Energy Systems Inc. 2 = Supplier 3 = Customer or Customer Agency 4 = Third Party	A = Approval Required D = Document Required O = Observation Point (Requires 14 calendar days advanced notification) R = Review Required W = Witness Point (Requires 14 calendar days advanced notification)	Project: <b>2XTrent 60 WLE</b>	
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Project: <b>2XTrent 60 WLE</b>												
				Doc.: GEDXXXXXX			Rev.: 000					

				RESPONSIBLE PARTY				
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
Balanced Rotor								
29	Rotor: iron sheet and winding inspections	Supplier Procedure	Drawing	R	D			
30	Machined rotor: dimensional and geometric inspection	Supplier Procedure	Drawing	R	D			
31	Balancing inspection (pre-balancing)	Supplier Procedure	Drawing	R	D			
32	Electrical and dielectrical inspections	Supplier Procedure	Drawing	R	D			
Assembled Stator								
33	Stacked lantern <ul style="list-style-type: none"> <li>Sheet dimensional inspection</li> <li>Magnetization test</li> </ul>	Supplier Procedure	Drawing	R	D			
34	Wound lantern: electrical and dielectrical inspections during winding, before and after VPI	Supplier Procedure	Drawing	R	D			
35	Machined frame <ul style="list-style-type: none"> <li>Dimensional inspection</li> <li>Geometrical inspection</li> </ul>	Supplier Procedure	Drawing	R	D			
36	Assembled stator: electrical and dielectrical inspections	Supplier Procedure	Drawing	R	D			
General Assembly and Tests								
37	Generator general assembly <ul style="list-style-type: none"> <li>Air gap</li> <li>Clearance of rotor readings</li> </ul>	Drawing	Drawing	R	D			
38	Generator pass-off test	Supplier Procedure	Supplier Procedure	O	D			All units on contract
39	Test machine on bench <ul style="list-style-type: none"> <li>Generator performance type test on first machine of a new design</li> <li>Excitation regulation static tests on single cubicle (GCP)</li> <li>Bearings inspection and insulation measurement</li> </ul>	Approved Procedure	Test Reports	W	D			First of design only
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				RESPONSIBLE PARTY				
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
40	Final inspection <ul style="list-style-type: none"> <li>Nameplate checking</li> <li>Final dimensional interface</li> <li>Outline dimensional readings</li> <li>Preparation, cleanliness before painting</li> <li>Paint thickness and adhesion</li> </ul>	GQP F.2.5	Drawing, Specification & Purchase Order	O	D	O		
41	Shipping <ul style="list-style-type: none"> <li>Identification inspection</li> <li>Protection inspection</li> <li>Packaging inspection for shipping</li> <li>Weight recording</li> </ul>	GQP F.2.5	Drawing, Specification & Purchase Order	R	D			
42	Documentation review	GQP F.2.5	Purchase Order	O	D			
43	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Generator Control Panel

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Dimensional inspection of entry and connection locations	Supplier Procedure	Approved Drawing	R	D			
2	Grounding facilities inspection	Supplier Procedure	Approved Drawing	R	D			
3	Continuity test	Supplier Procedure	Supplier Procedure	R	D			
4	Simulation test/factory acceptance test (FAT)	Approved Procedure	Approved Procedure	O	D			
6	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	GQP F.2.5	Specification & Purchase Order	O	D			
7	Documentation review	GQP F.2.5	Purchase Order	O	D			
8	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE		Doc.: GEDXXXXXX
		Rev.: 000

# Mineral Lube Oil Console

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Piping Material Certification	WI F.2.4.A	EN 10204 2.1	V	D			Certificate of Conformance
2	100% visual examination of completed pipe welds and dimensional spot checks	GEM 0028 & GEM 0031	GEM 0028 & GEM 0031	R	D			
3	<ul style="list-style-type: none"> <li>5% Radiographic testing of all butt welds</li> <li>100% dye penetrant inspection of branch, socket, and seal welds</li> </ul>	GEM 0050, GEM 0129	ANSI B31.3 & Normal Fluid Service	R	D			
4	<ul style="list-style-type: none"> <li>Hydrotest and visual examination of lube oil piping</li> <li>All pipe spools to be tested to procedure and drawing requirements</li> </ul>	GEM 0030 & GEM 0028	Zero Leaks & GEM 0050	R	D			
5	Record heat numbers of pipe spool components and consumables on pipe spool drawing	Drawing	Recorded on Drawing	R	D			
6	Visual inspection of reservoir cleanliness	WI F.2.4.A	Cleanliness	R	D			
7	Visual inspection of oil pumps	WI F.2.4.A	Drawing Tolerances & Data Sheets	R	D			Manufacturer's Certificate of Conformance
8	Visual inspection of electric motors	WI F.2.4.A	Approved Drawing & Data Sheets	R	D			Manufacturer's Certificate of Conformance and Hazardous Area Certification
9	Electric motor test certification	Manufacturer's Routine Test Report	Approved Drawing & Data Sheets	R	D			
10	<ul style="list-style-type: none"> <li>Insulation resistance test</li> <li>Wiring continuity test</li> </ul>	GEM 0047	GEM 0047	R	D			
11	Instrumentation line leak test	GEM 0042	Zero leaks	R	D			
12	Flushing of complete console	GEM 0038	GEM 0038	R	D			
13	Functional test	API- 614	Approved Procedure	R	D			
14	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Dimensional inspection - reservoir and connection points</li> <li>Cleaning</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Standard Paint Procedure & GQP F.2.5	Drawing Tolerances & Contract Compliance	O, D				Cleanliness; complete purge of test fluid and capped or sealed. Pipework and pumps to be drained and inspected for cleanliness. Verify all interconnects have been blanked off for shipment.
15	Documentation review	GQP F.2.5	Purchase Order	O	D			Instrument and relief valve calibration records
16	Shipping release (Required for supplier to ship to R-R)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000



# Water Injection System

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Pressure containing parts material certifications	Purchase Order	Material Specification	R	D			
2	Visual and dimensional inspection of skid	Supplier's Procedure	Approved Drawing & Cleanliness	R	D			
3	All vessels have been accepted by the proper authority and certificates issued	Supplier's Procedure	Purchase Order	R	D			
4	<ul style="list-style-type: none"> <li>Wiring continuity test</li> <li>Insulation resistance test</li> </ul>	Supplier's Procedure	Supplier's Procedure	R, D	D			
5	Visual inspection of electric motors	WI F.2.4.A	Approved Drawing & Data Sheets	R	D			Manufacturer's Certificate of Conformance Hazardous Area Certification
6	Electric motor test certification	Manufacturer Routine Test Report	Approved Drawing & Data Sheets	R	D			
7	Operational and simulation testing	Supplier's Procedure	Purchase Order	O	D			
8	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional and nameplate inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	R-R approved Paint Procedure & GQP F.2.5	Drawing Tolerances & GQP F.2.5	O	D			Cleanliness; complete purge of test water and capped or sealed. Pipework and pumps to be drained and inspected for cleanliness. Verify all interconnects have been blanked off for shipment.
9	Documentation review	GQP F.2.5	Purchase Order	O	D			Instrument and relief valve calibration records
10	Shipping release (Required for supplier to ship to R-R)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Liquid Fuel Forwarding Skid

REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
1	Pressure containing parts material certifications	Purchase Order	Material Specification	R	D			
2	Pipe fabrication <ul style="list-style-type: none"> <li>100% visual examination of completed welds and dimensional spot checks</li> </ul>	Supplier's Approved Procedure	ANSI B31.3 & Normal Fluid Service	R	D			
3	NDE: <ul style="list-style-type: none"> <li>100% Radiographic testing of all butt welds</li> <li>100% dye penetrant inspection of branch, socket, and seal welds</li> </ul>	Supplier's Approved Procedure	ANSI B31.3 & Normal Fluid Service	R	D			
4	<ul style="list-style-type: none"> <li>Hydrotest and visual examination of fuel piping</li> <li>All pipe spools to be tested to procedure and drawing requirements</li> </ul>	Supplier's Approved Procedure	Zero Leaks	R	D			
5	Visual and dimensional inspection of skid	Approved Procedure	Approved Drawing & Cleanliness	R	D			
6	Visual inspection of electric motors	WI F.2.4.A	Approved drawing & data sheets	R	D			Manufacturer's Certificate of Conformance and Hazardous Area Certification
7	Electric motor test certification	Manufacturer Routine Test Report	Approved drawing & data sheet	R	D			
8	All vessels have been accepted by the proper authority and certificates issued	Approved Procedure	Purchase Order	R	D			
9	<ul style="list-style-type: none"> <li>Wiring continuity test</li> <li>Insulation resistance test</li> </ul>	Approved Procedure	Approved Procedure	R, D	D			
10	Operational and simulation testing	Approved Procedure	Purchase Order	O	D			Includes verification of Kates valve.
11	Final inspection <ul style="list-style-type: none"> <li>Paint</li> <li>Where specified, protective coating and preservation</li> <li>Dimensional and nameplate inspection</li> <li>Preparation for shipment</li> <li>Tagging</li> </ul>	Standard Paint Procedure & GQP F.2.5	Drawing Tolerances & GQP F.2.5	O	D			Cleanliness; complete purge of test water and capped or sealed. Pipework and pumps to be drained and inspected for cleanliness. Verify all interconnects have been blanked off for shipment.
12	Documentation review	GQP F.2.5	Purchase Order	O	D			Instrument and relief valve calibration records
13	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Trent Testing, Packaging, and Shipping

				RESPONSIBLE PARTY				
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
Testing of Packaged Unit								
1	Fuel system piping assembly pressure test	GEM 0042 GEM 0077	GEM 0042 GEM 0077	R, D				
2	<ul style="list-style-type: none"><li>Insulation resistance test</li><li>Wiring continuity test</li></ul>	GEM 0047	GEM 0047	R, D				
3	P & ID Check	GQPFF.2.5.R	Drawing requirements	R, D				
4	Loop Check	LOP F.2.5.AJ	Drawing requirements	R, D				
5	Flushing of GT Lube Oil system	GEM 0064	GEM 0064	R, D				
6	After flushing, reservoirs, consoles, and pipework to be drained and inspected for cleanliness	Check List	Specification	R				
7	Verify that all test and interconnection points have been blanked off for shipping	Check List	Specification	R				
8	Verify main component serial numbers	Check List	Specification	R, D				
9	If applicable, ensure punch list is complete and approved by RRESI Quality	Punch List	Completed Punch List	R, D				
Final Inspection of Packaged Unit								
10	Weighing of unit	GEM 0013	GEM 0013	R, D				
11	Final inspection <ul style="list-style-type: none"><li>Paint</li><li>Dimensional inspection of customer connections</li><li>Preparation for shipment</li><li>Tagging</li><li>Nameplates</li><li>Rotation arrows</li></ul>	GEM 0056 & GQP F.2.5	Drawing Tolerances & GQP F.2.5	R		O		Cleanliness; complete purge of test fluids and capped or sealed. Pipework and pumps to be drained and inspected for cleanliness. Verify all interconnects have been blanked off for shipment.
12	Documentation review <ul style="list-style-type: none"><li>RRESI QA to prepare unit Certificate of Conformance for all above activities</li></ul>	GQP F.2.5	Purchase Order	R, D				
13	Shipping release	WI F.2.6.A	WI F.2.6.A	W				

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Project: 2XTrent 60 WLE

Doc.: GEDXXXXXX

Rev.: 000

# Abbreviations

AES	Application Engineering Specification
ATEX	Atmospheres Explosibles
AWS	American Welding Society
CE	Conformité Européenne (French for European Conformity)
GCP	Generator Control Panel
GEM	Global Engineering Method
GER	Global Engineering Reference
GPS	Global Procurement Specification
ISO	International Standards Organization
LOP	Local Operating Procedure
MPI	Magnetic Particle Inspection
NDE	Non-Destructive Examination
NDT	Non-Destructive Testing
PED	Pressure Equipment Directive
PQR	Procedure Qualification Record
UCP	Unit Control Panel
STP	Standard Test Procedure
UT	Ultrasonic Testing
VPI	Vacuum Pressure Impregnation
WI	Work Instruction
WPS	Welding Procedure Specification
WPQ	Welder Performance Qualification

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Project: 2XTrent 60 WLE	Doc.: GEDXXXXXX Rev.: 000

MECHANICAL CUSTOMER CONNECTIONS - RH REMOVAL UNIT (SHOWN)

CNTN	SIZE	CLASS (RATING)	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
M003	3.00"	150#	RF	CUSTOMER COOLANT SUPPLY	92.28	-179.17	-76.46	2344	-4551	-1942
M004	3.00"	150#	RF	CUSTOMER COOLANT RETURN	92.28	-187.56	-76.46	2344	-4764	-1942
M021A	2.00"	1500#	RF	DEMINERALIZED WATER SUPPLY - (GAS TURBINE SKID)	93.66	-54.76	-72.83	2379	-1391	-1850
M024	1.00"	CPLG	NPT(F)	WATER INJECTION DRAIN	88.31	-58.07	-87.48	2243	-1475	-2222
M105	1.00"	BALL VALVE	NPT(F)	GAS TURBINE OIL RESERVOIR TANK DRAIN	95.20	-187.56	-86.89	2418	-4764	-2207
M106	-	CGA - 580		ACCUMULATOR CHARGE POINT	57.99	-196.14	-41.26	1473	-4982	-1048
M107	1.00"	QUICK CONNECT		GAS TURBINE OIL RESERVOIR TANK FILL POINT	46.57	-162.72	-54.53	1183	-4133	-1385
M109	0.50"	BALL VALVE	NPT(F)	GAS TURBINE OIL RESERVOIR TANK SAMPLING POINT	93.50	-179.17	-86.89	2375	-4551	-2207
M130	4.00"	150#	RF	GAS TURBINE OIL DEMISTER VENT AT DEMISTER	39.49	-176.57	169.25	1003	-4485	4299
M200B	0.75"		OD TUBE	JACKING OIL SUPPLY (AT AC GENERATOR)	-71.85	411.61	-4.33	-1825	10455	-110
M201B	0.75"		OD TUBE	JACKING OIL SUPPLY (AT AC GENERATOR)	-71.85	409.45	-4.33	-1825	10400	-110
M206B	2.00"	150#	RF	MINERAL LUBE OIL MAIN PUMP SUCTION (AT AC GENERATOR)	-72.68	457.60	-16.14	-1846	11623	-410
M207B	1.25"	150#	RF	MINERAL LUBE OIL MAIN PUMP DISCHARGE (AT AC GENERATOR)	-72.68	465.43	-16.34	-1846	11822	-415
M208B	1.50"	150#	RF	MINERAL LUBE OIL SUPPLY (AT AC GENERATOR)	-72.64	405.39	-2.56	-1845	10297	-65
M209B	5.00"	150#	RF	MINERAL LUBE OIL RETURN (AT AC GENERATOR)	-78.94	407.36	-19.61	-2005	10347	-498
M300	1.50"	CPLG	NPT(F)	INSTRUMENT AIR SUPPLY	88.31	-301.97	-71.97	2243	-7670	-1828
M313A	0.75"	QUICK CONNECT		AIR SUPPLY TO WATER WASH TANK	91.34	-222.44	-84.65	2320	-5650	-2150
M398	1.00"	CPLG	NPT(F)	LIQUID FUEL PURGE AIR DRAIN	88.30	-69.88	-87.48	2243	-1775	-2222
M410	3.00"	600#	RF	FUEL GAS SUPPLY - GAS TURBINE SKID EDGE CONNECTION	92.83	-121.54	-82.95	2358	-3087	-2107
M411	3.00"	150#	RF	FUEL GAS VENT TO ATMOSPHERE	92.87	-121.54	-74.05	2359	-3087	-1881
M500	-	FLANGE		GAS TURBINE EXHAUST FLANGE CONNECTION	135.39	89.72	0	3439	2279	0
M503A	2.00"	900#	RF	LIQUID FUEL SUPPLY TO GT SKID (AT GT SKID)	93.66	-160.98	-80.83	2379	-4089	-2053
M504	2.00"	150#	RF	LIQUID FUEL RETURN	93.35	-160.98	-88.66	2371	-4089	-2252
M505	1.00"	CPLG	NPT(F)	LIQUID FUEL DRAIN	89.19	-159.23	-85.35	2265	-4044	-2168
M601B	0.75"	QUICK CONNECT		SOAK WASH SUPPLY TO GAS TURBINE	91.54	-222.44	-88.58	2325	-5650	-2250
M607	1.00"	BALL VALVE	NPT(F)	ISI DRAIN	92.72	-140.55	-88.39	2355	-3570	-2245
M611	1.00"	CPLG	NPT(F)	ISI WET COMPRESSION ARRAY/RADIAL INTAKE PLENUM DRAIN	88.31	-296.89	-92.09	2243	-7541	-2339
M612	1.00"	BALL VALVE	NPT(F)	WATER WASH - MANUAL DRAIN	94.05	70.51	-88.39	2389	2533	-2245
M613	3.00"	150#	RF	P30 COOLANT SUPPLY TO SKID	92.09	70.51	-88.70	2339	1791	-2253
M614	3.00"	150#	RF	P30 COOLANT RETURN FROM SKID	92.09	79.57	-88.70	2339	2021	-2253
M615	1.00"	CPLG	NPT(F)	P30 DRAIN	88.31	87.76	-88.39	2243	2229	-2245
M618A	1.00"	CPLG	NPT(F)	WATER FLUSH SUPPLY TO GT SKID (AT GT SKID)	89.19	-162.77	-85.35	2265	-4134	-2168
M628B	0.75"	1500#	RF	ISI WET COMPRESSION WATER GT SKID MANIFOLD #1 SUPPLY	92.52	-260.39	-79.37	2350	-6614	-2016
M629B	1.00"	1500#	RF	ISI WET COMPRESSION WATER GT SKID MANIFOLD #2 SUPPLY	92.52	-259.49	-88.90	2350	-6591	-2258
M631	2.00"	150 #	RF	ISI WET COMPRESSION WATER GT SKID PLANT RETURN	92.52	-248.98	-77.76	2350	-6324	-1975
M633B	0.50"	COMP		ISI INLET FOGGING NOZZLE ARRAY #1 SUPPLY INLET	152.28	-522.20	297.16	3868	-13264	7548
M634B	0.75"	COMP		ISI INLET FOGGING NOZZLE ARRAY #2 SUPPLY INLET	152.28	-519.25	297.16	3868	-13189	7548
M635B	0.75"	COMP		ISI INLET FOGGING NOZZLE ARRAY #3 SUPPLY INLET	152.28	-516.30	297.16	3868	-13114	7548
M636A	1.00"	CPLG	NPT	FILTER HOUSE DRAIN FROM DUCT	134.25	-674.29	237.13	3410	-17127	6023
M636B	1.00"	CPLG	NPT	FILTER HOUSE DRAIN FROM DUCT	-134.25	-674.29	237.13	-3410	-17127	6023
M660A	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-248.98	-94.72	2254	-6324	-2406
M660B	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-167.32	-94.72	2254	-4250	-2406
M660C	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-78.74	-94.72	2254	-2000	-2406
M660D	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-23.15	-94.72	2254	-588	-2406
M660E	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	99.72	-94.72	2254	2533	-2406
M660F	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	99.72	-94.72	-2254	2533	-2406
M660G	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-23.15	-94.72	-2254	-588	-2406
M660H	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-78.74	-94.72	-2254	-2000	-2406
M660J	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-167.32	-94.72	-2254	-4250	-2406
M660K	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-259.84	-94.72	-2254	-6600	-2406
M701	1.50"	OD TUBE		CO2 INLET GAS TURBINE ENCLOSURE	88.31	145.24	-88.94	2243	3689	-2259

NOTES:

1.  DENOTES ROLLS-ROYCE DATUM.
2. ALL BOLT HOLES IN CUSTOMER CONNECTION FLANGES TO STRADDLE CENTERLINES, UNLESS OTHERWISE NOTED.
3. ALL CUSTOMER PIPED VENT LINES MUST HAVE A CONTINUOUS VERTICAL RISE (NO TRAPS OR LOW POINTS). CUSTOMER DRAIN LINES TO HAVE A MINIMUM SLOPE OF 0.50in/ft (142mm/m) TOWARD THE RESERVOIR PER API - 614. INTERCONNECT PIPING AND TUBING SHOULD HAVE A CONTINUOUS SLOPE TO PREVENT AIR POCKETS.
4. GAS TURBINE SKID DRAIN CONNECTIONS M660A THRU M660K MUST BE CONNECTED AT ALL TIMES TO A WASTE HYDROCARBON TANK (BY OTHERS). ALL PIPE WORK TO BE SIZED NO SMALLER THAN SKID EDGE CONNECTION AND MUST HAVE A CONTINUOUS SLOPE TO DRAIN. A FLUID TYPE "U" TRAP MUST BE FITTED IN THE PIPE WORK BETWEEN TANK AND GAS TURBINE SKID.
5. TUBE FITTINGS ARE COMPRESSION TYPE 316 SST.
6. MECHANICAL CUSTOMER CONNECTIONS ARE LOCATED GENERALLY WITHIN 0.25 INCH (7mm) OF DIMENSION SPECIFIED. FINAL LOCATIONS TO BE CONFIRMED IN THE FIELD.
7. WIRING TO BE IEC CODE FOR ZONE I, GROUP D, CLASSIFICATION INSIDE ENCLOSURE.
8. REFER TO ELECTRICAL INTERFACE DRAWING GED00045696 FOR TERMINAL AND DEVICE CODE NUMBERS.
9. REFER TO BOLTING AND GROUTING PLAN DRAWING GED00045691 FOR FOUNDATION BOLTING PLAN.
10.  DENOTES CUSTOMER CONNECTIONS.
11. B.O.S. = BOTTOM OF STEEL.
12. SPECIAL "QUICK CONNECT" ADAPTERS SUPPLIED TO INSTALL ON CUSTOMER SUPPLIED FILL HOSE.
13. MAXIMUM PIPING FOR CO2 CABINET NOT TO EXCEED 394 INCHES (10000mm) AND TO CONTAIN A MAXIMUM OF 8 ELBOWS.
14. SEE ROLLS-ROYCE CONTROLS OUTLINE DRAWINGS GED00023951 FOR UNIT CONTROL PANEL DIMENSIONS.
15. CONTROL CABINET TO BE MOUNTED BY OTHERS CABLE INSTALLATION. NOT TO EXCEED 3937 INCHES (100000mm).
16. WATER INJECTION SKID TO BE POSITIONED NOT TO EXCEED 315 INCHES (8000mm) FROM CONNECTION M021A TO M021B.
17.  DENOTES AIR FLOW DIRECTION
- 18.
19. FINISH PAINTING IN FIELD TO BE COMPLETED BY OTHERS, UTILIZING MATERIALS AND PROCEDURES EQUAL TO MANUFACTURER'S STANDARD.
20. MINERAL LUBE OIL SKID TO BE POSITIONED SO THE HORIZONTAL DISTANCE FROM CONNECTION M208A TO M208B DOES NOT EXCEED 196.85 INCHES (5000mm) AND THE ELEVATION CHANGE DOES NOT EXCEED 60 INCHES (1524mm). THE PIPING MAY CONTAIN A MAXIMUM OF 10 ELBOWS AND 1 TEE. MINERAL LUBE OIL SKID MUST BE LOCATED IN A SAFE AREA (NON-HAZARDOUS ZONE).
21. LIQUID FUEL FORWARDING SKID TO BE POSITIONED IN SUCH A WAY THAT THE PRESSURE DROP DOES NOT EXCEED 21.76 PSI (150kPa).

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3RD ANGLE PROJECTION

ENGR. 21  
ENGR. 11 SL-17  
ENGR. 011 SH  
ENGR. 011 KMD  
ENGR. 011 ACK  
ENGR. 011 GED0000

I	40157.01.102 RELEASE CERTIFIED, UPDATED TABLE, ADDED INCH DIMENSIONS, ADDED CONNECTION M363A, M363B	OSMARIO ADK
O	40157.01 INITIAL RELEASE	OSMARIO ADK
REV NO	ECO NO / DESCRIPTION	DATE
ISSUE	REVISION HISTORY	BY



ROLLS-ROYCE ENERGY SYSTEMS INC. ROLLS-ROYCE POWER INTERNATIONAL  
WEST GORDON 2013 4550 US METU, GORDON 017 017 ENGLAND

GENERAL ARRANGEMENT  
TRENT 60 WLE

SIZE	A1	REV	1
SCALE	NTS		


12 11 10 9 8 7 6 5 4 3 2 1

⊙ MECHANICAL CUSTOMER CONNECTIONS - LH REMOVAL UNIT (NOT SHOWN)

CNTN	SIZE	CLASS (RATING)	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
M003	3.00"	150#	RF	CUSTOMER COOLANT SUPPLY	92.28	-179.17	-76.46	2344	-4551	-1942
M004	3.00"	150#	RF	CUSTOMER COOLANT RETURN	92.28	-187.56	-76.46	2344	-4764	-1942
M021A	2.00"	1500#	RF	DEMINERALIZED WATER SUPPLY - (GAS TURBINE SKID)	-93.66	-96.93	-76.69	-2379	-2462	-1948
M024	1.00"	CPLG	NPT(F)	WATER INJECTION DRAIN	-88.30	-69.88	-91.43	-2243	-1775	-2322
M105	1.00"	BALL VALVE	NPT(F)	GAS TURBINE OIL RESERVOIR TANK DRAIN	95.20	-187.56	-86.89	2418	-4764	-2207
M106	-	CGA - 580	-	ACCUMULATOR CHARGE POINT	57.99	-196.14	-41.26	1473	-4982	-1048
M107	1.00"	QUICK CONNECT	-	GAS TURBINE OIL RESERVOIR TANK FILL POINT	46.57	-162.72	-54.53	1183	-4133	-1385
M109	0.50"	BALL VALVE	NPT(F)	GAS TURBINE OIL RESERVOIR TANK SAMPLING POINT	93.50	-179.17	-86.89	2375	-4551	-2207
M130	4.00"	150#	RF	GAS TURBINE OIL DEMISTER VENT AT DEMISTER	39.49	-176.57	169.25	1003	-4485	4299
M200B	0.75"		OD TUBE	JACKING OIL SUPPLY (AT AC GENERATOR)	-71.85	411.61	-4.33	-1825	10455	-110
M201B	0.75"		OD TUBE	JACKING OIL SUPPLY (AT AC GENERATOR)	-71.85	409.45	-4.33	-1825	10400	-110
M206B	2.00"	150#	RF	MINERAL LUBE OIL MAIN PUMP SUCTION (AT AC GENERATOR)	-72.68	457.60	-16.14	-1846	11623	-410
M207B	1.25"	150#	RF	MINERAL LUBE OIL MAIN PUMP DISCHARGE (AT AC GENERATOR)	-72.68	465.43	-16.34	-1846	11822	-415
M208B	1.50"	150#	RF	MINERAL LUBE OIL SUPPLY (AT AC GENERATOR)	-72.64	405.39	-2.56	-1845	10297	-65
M209B	5.00"	150#	RF	MINERAL LUBE OIL RETURN (AT AC GENERATOR)	-78.94	407.36	-19.61	-2005	10347	-498
M300	1.50"	CPLG	NPT(F)	INSTRUMENT AIR SUPPLY	88.31	-301.97	-71.97	2243	-7670	-1828
M313A	0.75"	QUICK CONNECT	-	AIR SUPPLY TO WATER WASH TANK	91.34	-222.44	-84.65	2320	-5650	-2150
M398	1.00"	CPLG	NPT(F)	LIQUID FUEL PURGE AIR DRAIN	-88.30	-58.07	-91.43	-2243	-1475	-2322
M410	3.00"	600#	RF	FUEL GAS SUPPLY - GAS TURBINE SKID EDGE CONNECTION	-92.68	-127.68	-77.09	-2354	-3243	-1958
M411	3.00"	150#	RF	FUEL GAS VENT TO ATMOSPHERE	-92.68	-118.82	-77.09	-2354	-3018	-1958
M500	-	FLANGE	-	GAS TURBINE EXHAUST FLANGE CONNECTION	-135.39	89.72	0	-3439	2279	0
M503A	2.00"	900#	RF	LIQUID FUEL SUPPLY TO GT SKID (AT GT SKID)	93.66	-160.98	-80.83	2379	-4089	-2053
M504	2.00"	150#	RF	LIQUID FUEL RETURN	93.35	-160.98	-88.66	2371	-4089	-2252
M505	1.00"	CPLG	NPT(F)	LIQUID FUEL DRAIN	89.19	-159.23	-85.35	2265	-4044	-2168
M601B	0.75"	QUICK CONNECT	-	SOAK WASH SUPPLY TO GAS TURBINE	91.54	-222.44	-88.58	2325	-5650	-2250
M607	1.00"	BALL VALVE	NPT(F)	ISI DRAIN	92.72	-140.55	-88.39	2355	-3570	-2245
M611	1.00"	CPLG	NPT(F)	ISI WET COMPRESSION ARRAY/RADIAL INTAKE PLENUM DRAIN	88.31	-296.89	-92.09	2243	-7541	-2339
M612	1.00"	BALL VALVE	NPT(F)	WATER WASH - MANUAL DRAIN	94.05	70.51	-88.39	2389	2533	-2245
M613	3.00"	150#	RF	P30 COOLANT SUPPLY TO SKID	92.09	70.51	-88.70	2339	1791	-2253
M614	3.00"	150#	RF	P30 COOLANT RETURN FROM SKID	92.09	79.57	-88.70	2339	2021	-2253
M615	1.00"	CPLG	NPT(F)	P30 DRAIN	88.31	87.76	-88.39	2243	2229	-2245
M618A	1.00"	CPLG	NPT(F)	WATER FLUSH SUPPLY TO GT SKID (AT GT SKID)	89.19	-162.77	-85.35	2265	-4134	-2168
M628B	0.75"	1500#	RF	ISI WET COMPRESSION WATER GT SKID MANIFOLD #1 SUPPLY	92.52	-260.39	-79.37	2350	-6614	-2016
M629B	1.00"	1500#	RF	ISI WET COMPRESSION WATER GT SKID MANIFOLD #2 SUPPLY	92.52	-259.49	-88.90	2350	-6591	-2258
M631	2.00"	150 #	RF	ISI WET COMPRESSION WATER GT SKID PLANT RETURN	92.52	-248.98	-77.76	2350	-6324	-1975
M633B	0.50"	COMP	ISI	ISI INLET FOGGING NOZZLE ARRAY #1 SUPPLY INLET	152.28	-522.20	297.16	3868	-13264	7548
M634B	0.75"	COMP	ISI	ISI INLET FOGGING NOZZLE ARRAY #2 SUPPLY INLET	152.28	-519.25	297.16	3868	-13189	7548
M635B	0.75"	COMP	ISI	ISI INLET FOGGING NOZZLE ARRAY #3 SUPPLY INLET	152.28	-516.30	297.16	3868	-13114	7548
M636A	1.00"	CPLG	NPT	FILTER HOUSE DRAIN FROM DUCT	134.25	-674.29	237.13	3410	-17127	6023
M636B	1.00"	CPLG	NPT	FILTER HOUSE DRAIN FROM DUCT	-134.25	-674.29	237.13	-3410	-17127	6023
M660A	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-248.98	-94.72	2254	-6324	-2406
M660B	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-167.32	-94.72	2254	-4250	-2406
M660C	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-78.74	-94.72	2254	-2000	-2406
M660D	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	-23.15	-94.72	2254	-588	-2406
M660E	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	88.74	99.72	-94.72	2254	2533	-2406
M660F	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	99.72	-94.72	-2254	2533	-2406
M660G	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-23.15	-94.72	-2254	-588	-2406
M660H	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-78.74	-94.72	-2254	-2000	-2406
M660J	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-167.32	-94.72	-2254	-4250	-2406
M660K	1.00"	CPLG	NPT(F)	GAS TURBINE SKID DRAIN	-88.74	-259.84	-94.72	-2254	-6600	-2406
M701	1.50"		OD TUBE	CO2 INLET GAS TURBINE ENCLOSURE	-88.31	145.24	-88.94	-2243	3689	-2259

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3RD ANGLE PROJECTION  
ENGR. 24  
ENGR. 14 SL-F  
APPR. BY: SH  
CHKD. BY: KMD  
DRAWN BY: ADK  
DWG. DATE: 04/04/09

1	40157.01.102 ADDED NEW SHEET 2 WITH TABLE FOR LH REMOVAL	OSMARIO ADK
REV NO	ECO NO / DESCRIPTION	DATE BY
ISSUE	REVISION HISTORY	
 <b>Rolls-Royce</b>		
ROLLS-ROYCE ENERGY SYSTEMS INC. ROLLS-ROYCE POWER ENGINEERING AMBLY, CHESHIRE CV1 3LP ENGLAND		
GENERAL ARRANGEMENT TRENT 60 WLE		
SIZE	A1	REV L
SCALE: NTS	SHEET1	

UNIGRAPHICS  
DRAWING

12 11 10 9 8 7 6 5 4 3 2 1

12 11 10 9 8 7 6 5 4 3 2 1

© ELECTRICAL CUSTOMER CONNECTIONS - RH REMOVAL UNIT (SHOWN) AND LH REMOVAL UNIT (NOT SHOWN)

CNTN	SIZE	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
E201	2.50"	NPT	POWER SUPPLY TO FILTER HOUSE ASC FAN MOTOR	27.23	-604.40	149.19	692	-15352	3789
E202	0.75"	NPT	POWER SUPPLY TO ASC FILTER CONTROL PANEL	140.93	-585.00	262.45	3580	-14859	6666
E203	0.75"	NPT	POWER SUPPLY TO FILTER HOUSE ASC FAN MOTOR ANTI-CONDENSATION HEATER	27.23	-604.40	149.19	692	-15352	3789
E205	0.75"	NPT	PULSE CLEAN ENABLE PUSH BUTTON	140.93	-585.00	262.45	3580	-14859	6666
E206	0.75"	NPT	COMMUNICATION LINK FOR DISTRIBUTED I/O	140.93	-585.00	262.45	3580	-14859	6666
E209	0.75"	NPT(F)	GAS TURBINE OIL RESERVOIR HEATER	49.21	-192.48	-48.78	1250	-4889	-1239
E210	0.75"	NPT(F)	GAS TURBINE OIL RESERVOIR THERMOSTAT	49.21	-192.48	-46.26	1250	-4889	-1175
E230	UNDRILLED GLAND PLATE		ELECTRIC START MOTOR POWER SUPPLY	-91.22	-265.79	-89.17	-2317	-6751	-2265
E231	UNDRILLED GLAND PLATE		ELECTRIC START MOTOR THERMISTOR	-91.22	-265.79	-89.17	-2317	-6751	-2265
E240	1.00"	NPT(F)	HYDRAULIC PUMP MOTOR #1 POWER SUPPLY	-66.89	-190.20	-73.62	-1699	-4831	-1870
E241	1.00"	NPT(F)	HYDRAULIC PUMP MOTOR #2 POWER SUPPLY	-66.89	-171.81	-73.62	-1699	-4364	-1870
E242	1.00"	NPT(F)	HYDRAULIC PUMP MOTOR #1 ANTI-CONDENSATION HEATER	-65.24	-190.20	-73.62	-1657	-4831	-1870
E243	1.00"	NPT(F)	HYDRAULIC PUMP MOTOR #2 ANTI-CONDENSATION HEATER	-65.24	-171.81	-73.62	-1657	-4364	-1870
E252	0.75"	NPT	POWER TO GAS TURBINE ENCLOSURE LIGHTS	-81.61	-319.05	-39.33	-2073	-8104	-999
E253	0.75"	NPT	POWER TO GAS TURBINE ENCLOSURE EMERGENCY LIGHTS	-81.61	-318.35	-18.66	-2073	-8086	-474
E256	2.00"	NPT	GAS TURBINE ENCLOSURE #1 VENT FAN MOTOR POWER	-43.70	-58.74	187.76	-1110	-1492	4769
E257	0.75"	NPT	GAS TURBINE ENCLOSURE #1 VENT FAN MOTOR ANTI-CONDENSATION HEATER	-43.70	-58.74	187.76	-1110	-1492	4769
E259	2.00"	NPT	GAS TURBINE ENCLOSURE #2 VENT FAN MOTOR POWER	0	-58.74	187.76	0	-1492	4769
E260	0.75"	NPT	GAS TURBINE ENCLOSURE #2 VENT FAN MOTOR ANTI-CONDENSATION HEATER	0	-58.74	187.76	0	-1492	4769
E262	2.00"	NPT	GAS TURBINE ENCLOSURE #3 VENT FAN MOTOR POWER	43.70	-58.74	187.76	1110	-1492	4769
E263	0.75"	NPT	GAS TURBINE ENCLOSURE #3 VENT FAN MOTOR ANTI-CONDENSATION HEATER	43.70	-58.74	187.76	1110	-1492	4769
E265	1.00"	NPT	POWER TO GAS TURBINE ENCLOSURE SPACE HEATER	-39.92	-178.03	72.01	-1014	-4522	1829
E301	UNDRILLED GLAND PLATE		CUSTOMER CONNECTIONS TO EMV-1	13.50	-315.12	-89.92	343	-8004	-2284
E302	UNDRILLED GLAND PLATE		CUSTOMER CONNECTIONS TO EMV-2	50.35	-315.12	-89.92	1279	-8004	-2284
E401	0.75"	NPT	ASC FAN MOTOR STOP PUSH BUTTON	27.23	-604.40	149.19	692	-15352	3789
E700	UNDRILLED GLAND PLATE		COMMUNICATION SIGNALS AND POWER FROM FPGT-1 TO UCP	80.80	-320.38	55.71	2052	-8138	1415
E711	UNDRILLED GLAND PLATE		COMMUNICATION SIGNALS AND POWER FROM FPGT-1 TO FPGT-3	80.80	-320.38	55.71	2052	-8138	1415
E816	M20x1.50	ISO	HYDRAULIC PUMP MOTOR #1 STOP PUSH BUTTON	-56.73	-186.97	-73.74	-1441	-4749	-1873
E817	M20x1.50	ISO	HYDRAULIC PUMP MOTOR #2 STOP PUSH BUTTON	-56.73	-182.36	-73.74	-1441	-4632	-1873
E855	0.75"	NPT	GAS TURBINE ENCLOSURE #1 VENT FAN STOP PUSH BUTTON	-43.70	-58.74	187.76	-1110	-1492	4769
E858	0.75"	NPT	GAS TURBINE ENCLOSURE #2 VENT FAN STOP PUSH BUTTON	0	-58.74	187.76	0	-1492	4769
E861	0.75"	NPT	GAS TURBINE ENCLOSURE #3 VENT FAN STOP PUSH BUTTON	43.70	-58.74	187.76	1110	-1492	4769

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3RD ANGLE PROJECTION  
ENGR. 24  
ENGR. 11 SL-17  
ENGR. 811 SH  
CHKD. 811 KMD  
DRAWN BY: AOK  
DATE: 02/26/09

40157.01.T02 WAS SHEET 2, UPDATED CONNECTION TABLE, ADDED CONNECTION E201, E203, E205, E401		OSMAR10 AOK
REV NO	ECO NO / DESCRIPTION	DATE BY
ISSUE	REVISION HISTORY	
 <b>Rolls-Royce</b>		
ROLLS-ROYCE ENERGY SYSTEMS INC. ROLLS-ROYCE POWER INTERNATIONAL WEST GERRARD 2010 4550 USA WEST GERRARD 2010 4550 USA		
GENERAL ARRANGEMENT TRENT 60 WLE		
SCALE: 1 NTS		REV 1

UNIGRAPHICS  
DRAWING

12 11 10 9 8 7 6 5 4 3 2 1

12

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1



## APPROXIMATE WEIGHT OF COMPONENTS

GAS TURBINE INSTALLED	DRY WEIGHT lbs	WEIGHT kg
GAS TURBINE SKID AS SHIPPED	124989	56685
ROOF SECTION 1 ASSEMBLY	14952	6782
ROOF SECTION 2 ASSEMBLY	7650	3470
ROOF SECTION 3 ASSEMBLY	5049	2290
ROOF SECTION 4 ASSEMBLY	2535	1150
BLEED OUTLET PRIMARY SILENCER	5600	2540
BLEED OUTLET COWL	1303	591
VENTILATION OUTLET SILENCER	6570	2980
VENTILATION OUTLET FANS	8614	3000
VENTILATION OUTLET COWL	1984	900
VENTILATION INLET BEND	2346	1064
VENTILATION INLET DAMPER	562	255
VENTILATION INLET SILENCER	2425	1100
VENTILATION INLET VERTICAL DUCT	2976	1350
VENTILATION INLET FLEXIBLE	187	85
INSTALLED ITEMS		
IPBOV FLEXIBLE	794	360
COMBUSTION INTAKE FLEXIBLE	265	120
OIL MIST ELIMINATOR	551	250
EXHAUST TRANSITION	4361	1978
FLEXIBLE COUPLING	997	452
GAS TURBINE WLE	26015	11800



## APPROXIMATE WEIGHT OF COMPONENTS

EXTERNAL SKID ITEMS	DRY WEIGHT lbs	WEIGHT kg
CO2 CABINET FOR GAS TURBINE ENCLOSURE (NO CYLINDERS)	3300	1497
CO2 CYLINDERS (SHIPPED DRY)	3598	1632
WATER INJECTION SKID (DRY WEIGHT)	7048	3197
HP LIQUID FUEL FORWARDING SKID	5750	2608
WATER WASH CART	225	102
AC GENERATOR - COOLER	10142	4600
AC GENERATOR (AS SHIPPED)	242509	110000
MECHANICAL HANDLING SKID	4352	1974



## APPROXIMATE WEIGHT OF COMPONENTS

COMBINED FILTER HOUSE	DRY WEIGHT lbs	WEIGHT kg
LOWER SERVICE AIFH PLENUM - 26 WIDE	6834	3100
UPPER SERVICE AIFH PLENUM - 26 WIDE	6834	3100
LOWER ASC FILTER ASSEMBLY - 26 WIDE	9480	4300
UPPER ASC FILTER ASSEMBLY - 26 WIDE	10252	4650
UPPER REAR TRANSITION	3490	1583
LOWER REAR TRANSITION	6797	3083
EXTENSION DUCT - ISI	15644	7096
UPPER FRONT TRANSITION	4352	1974
LOWER FRONT TRANSITION	5966	2706
ASC SECONDARY AIR FAN	2690	1220
DUST CHUTE	3131	1420
TOTAL FOR COMBINED FILTER HOUSE	72470	34232

1	40157-01.T02 WAS SHEET 3, ADDED LBS TO TABLES, UPDATED COMBINED FILTER HOUSE WEIGHTS	OSMAR10 ADK
REV NO	ECO NO / DESCRIPTION	DATE
ISSUE	REVISION HISTORY	BY



Rolls-Royce

ROLLS-ROYCE ENERGY SYSTEMS, INC.  
WEST KENNA 2013-4550 USAROLLS-ROYCE POWER TECHNOLOGIES  
MILFORD, CONNECTICUT 06460 USAGENERAL ARRANGEMENT  
TRENT 60 WLE

SIZE	REV
A1	1

SCALE: NTS

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3RD ANGLE PROJECTION

ENGR. 24

ENGR. 11 SL-P

ENGR. 011 SH

CHKD. 011 KMD

DRAWN BY: ADK

DRG. DATE: 02/20/09

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UNIGRAPHICS  
DRAWING



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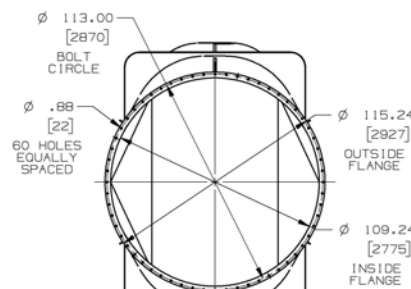
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1

COMBINED  
AIR INLET  
FILTERGT BLEED VALVE  
PLENUMGT VENTILATION  
AIR OUTLETAC GENERATOR  
COOLER

AC GENERATOR



DETAIL "C"

CENTER LINE OF FLANGE THERMAL MOVEMENT (COLD TO HOT) MAXIMUM  
+0.19 [+4.72mm] (Y AXIS/AXIAL)  
+0.73 [+18.48mm] (X AXIS/HORIZONTAL)

DIAMETER THERMAL MOVEMENT (COLD TO HOT) MAXIMUM  
+0.60 [+15.18mm]

FLANGE LOAD LIMIT MAXIMUM  
744.121bf [3.31kN]

EXHAUST  
FLANGE  
DETAIL "C"CONCRETE  
PLINTH  
(PROVIDED BY OTHERS)

M 636A

E 206 E 205 E 202

E 401 E 203 E 201

M 633B

M 634B

M 635B

E 302

E 301

M 611

M 300

M 601B

M 313A

M 410

M 411

M 612

M 615

M 613

M 614

M 398

M 021A

M 024

M 004

M 105

M 109

M 003

M 607

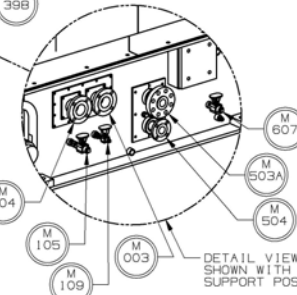
M 503A

M 504

M 629B

M 631

M 629B



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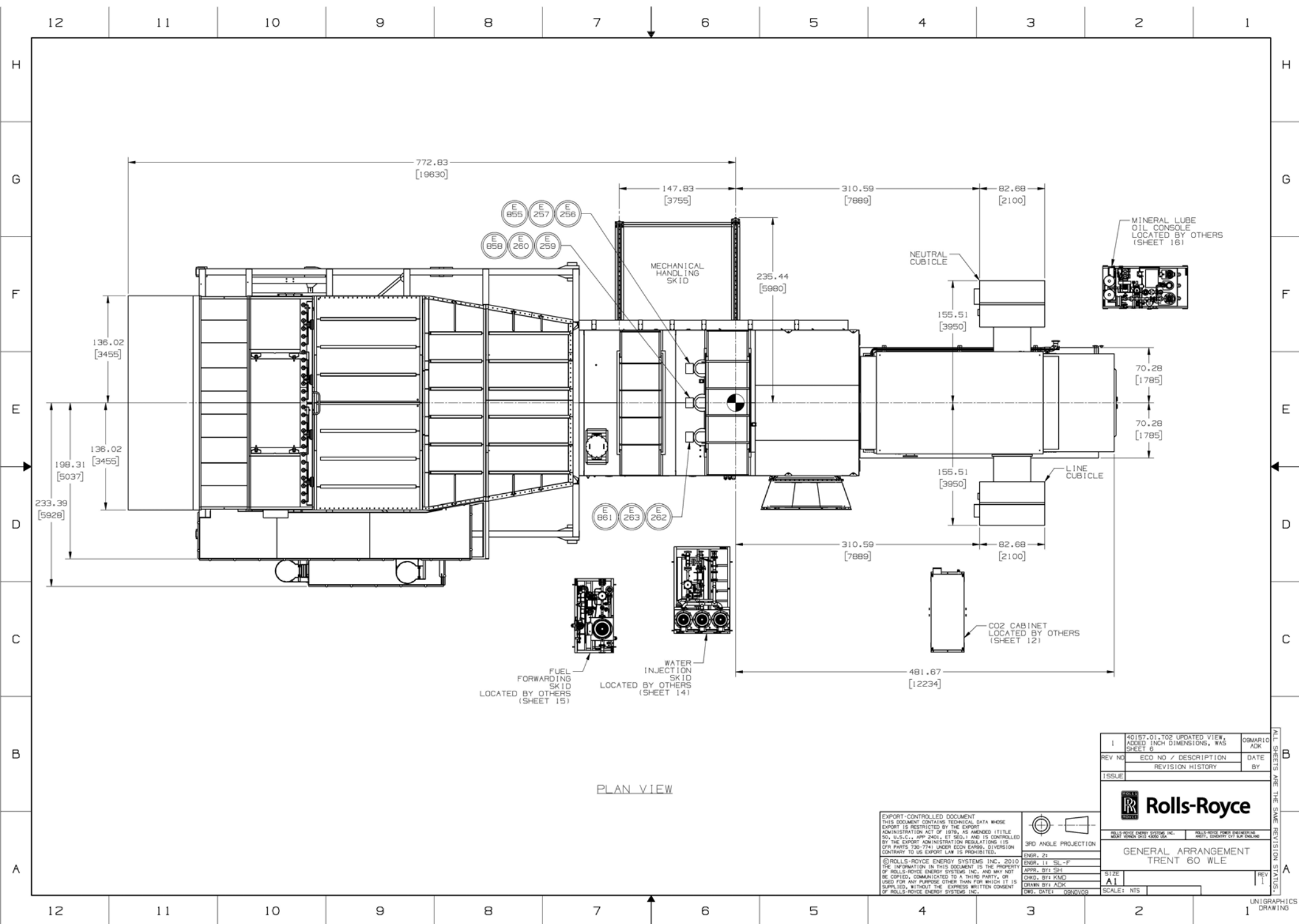
3RD ANGLE PROJECTION

ENGR. 24  
ENGR. UJ SL-P  
ENGR. BYI SH  
CHKD. BYI KMD  
DRAWN BYI ACK  
DRG. DATE1 02/20/09

1	40157-01-702 UPDATED VIEW, ADDED INCH DIMENSIONS, ADDED CONNECTION E201, E203, E205, E401, M363A WAS SHEET 4	OSMAR10 AKK
REV NO	ECO NO / DESCRIPTION	DATE
ISSUE	REVISION HISTORY	BY
<b>Rolls-Royce</b>		
<small>ROLLS-ROYCE ENERGY SYSTEMS INC. ROLLS-ROYCE POWER INTERNATIONAL WEST GERRARD 2013 4550 US INFILY, GERMANY 0117 51P ENGLAND</small>		
GENERAL ARRANGEMENT TRENT 60 WLE		
SIZE A1	SCALE1 NTS	REV 1

UNIGRAPHICS  
DRAWING





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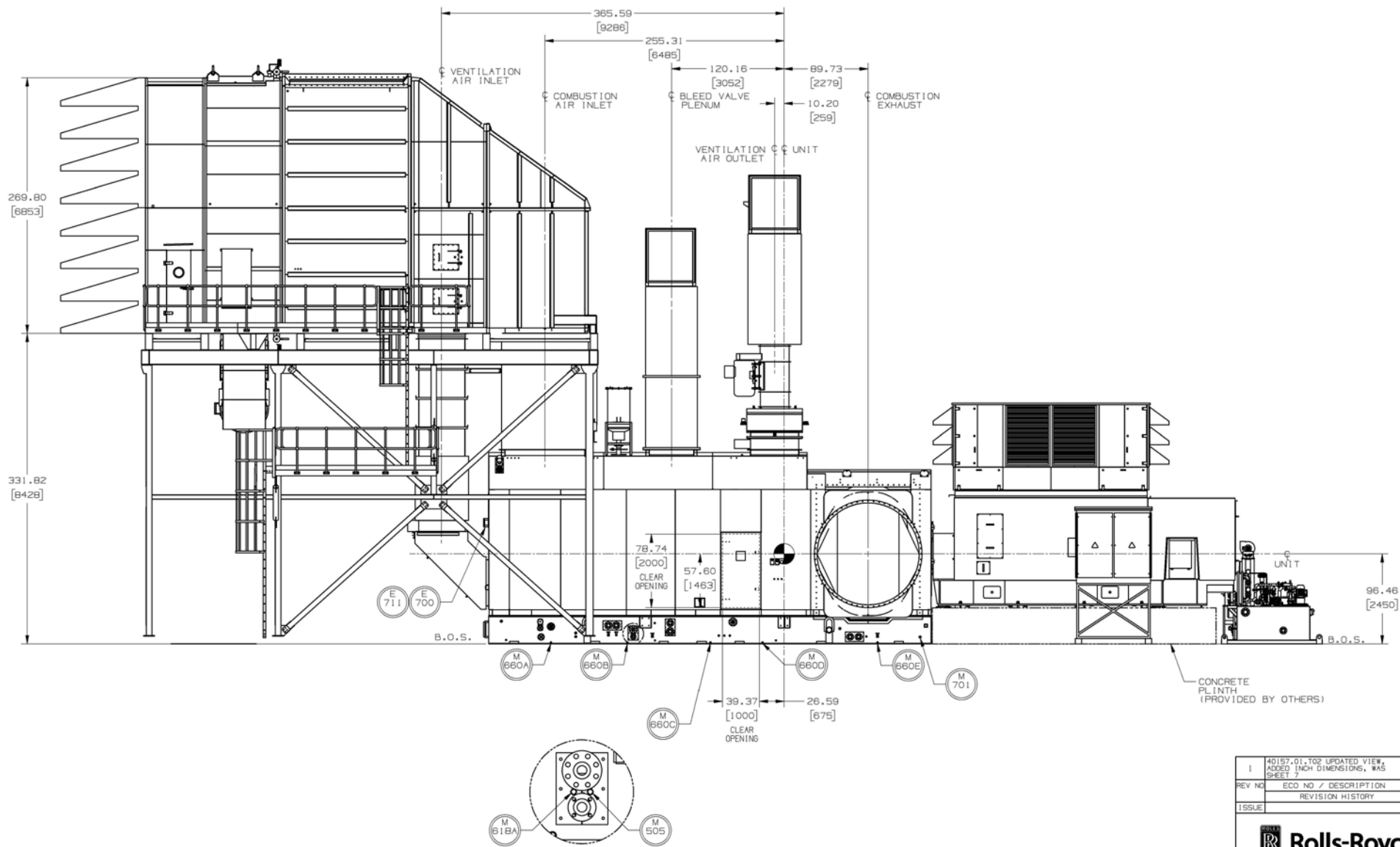
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UNIGRAPHICS  
DRAWING



PORT SIDE ELEVATION  
LIQUID FUEL AND WATER  
INJECTION SKIDS NOT SHOWN

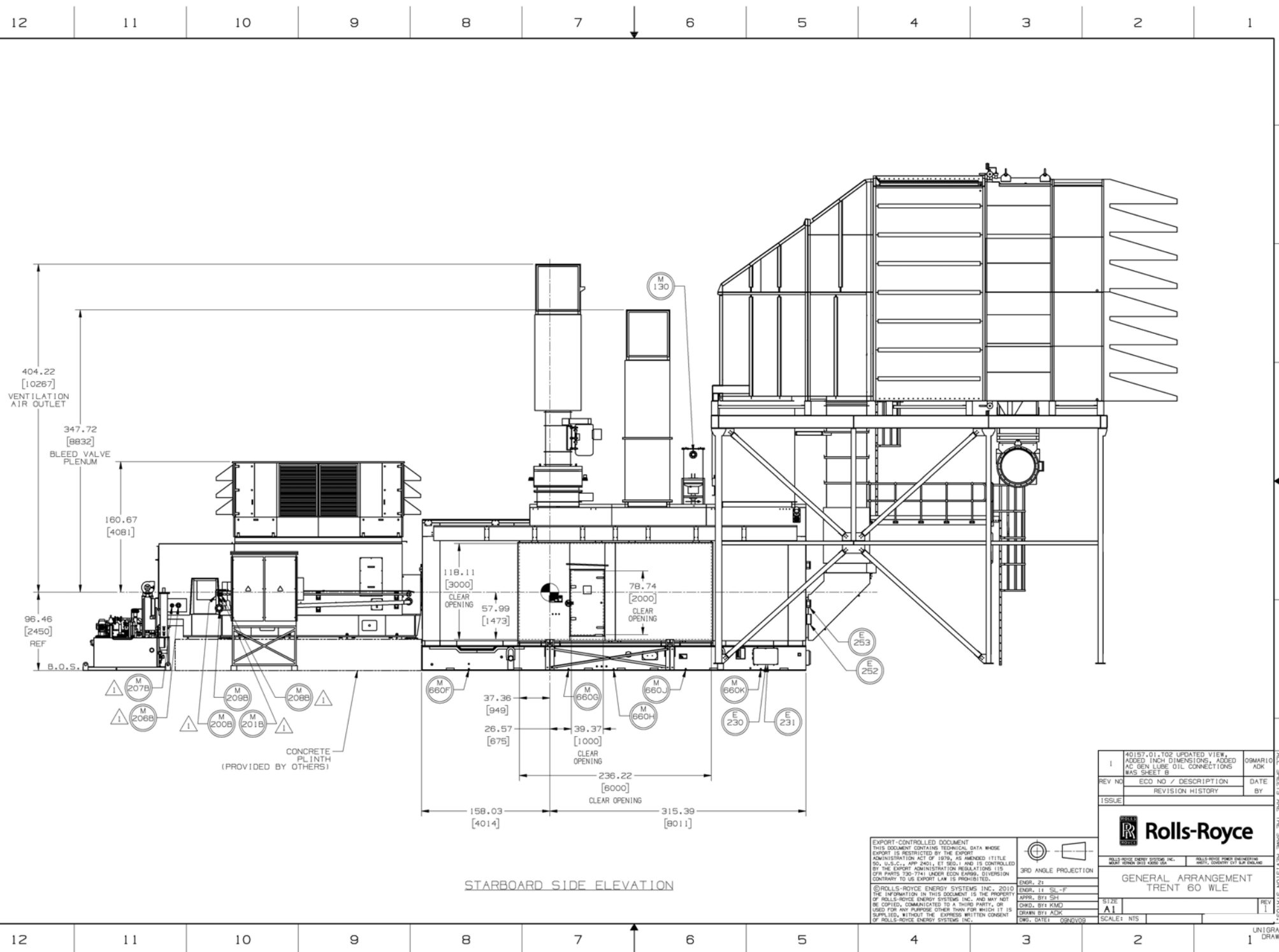
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ENGR. 24  
ENGR. 14 SL-7  
ENGR. 871 SH  
CHKD. 871 KMD  
DRAWN BY: ACK  
DWG. DATE: 02/20/09

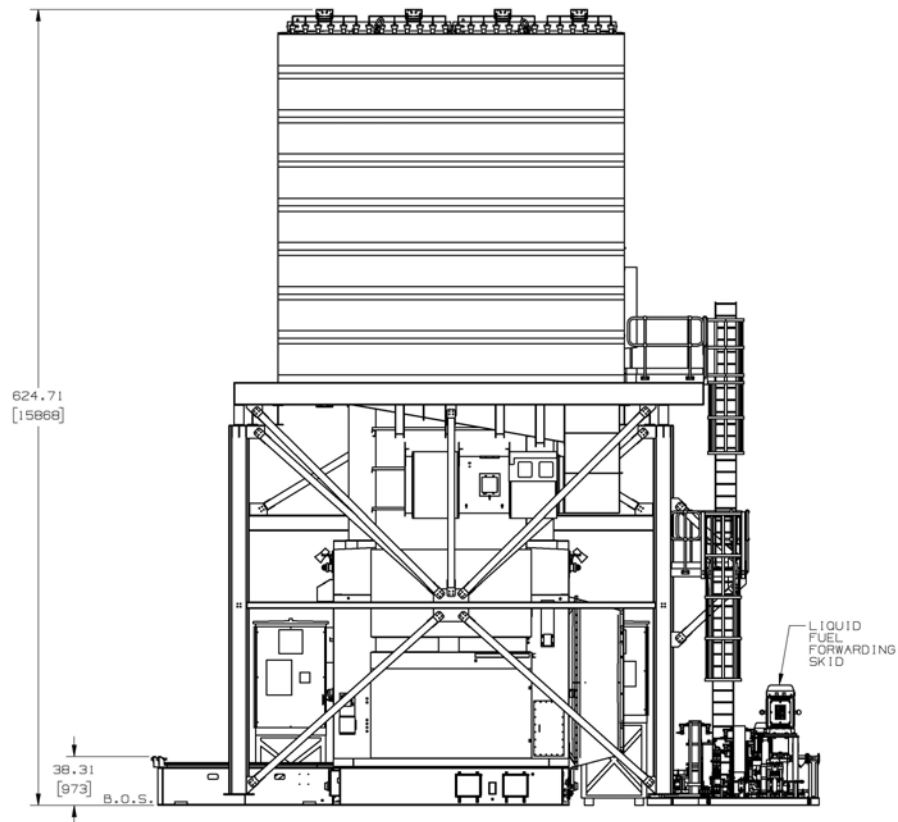
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REV NO	ECO NO / DESCRIPTION
DATE	BY
ISSUE	REVISION HISTORY



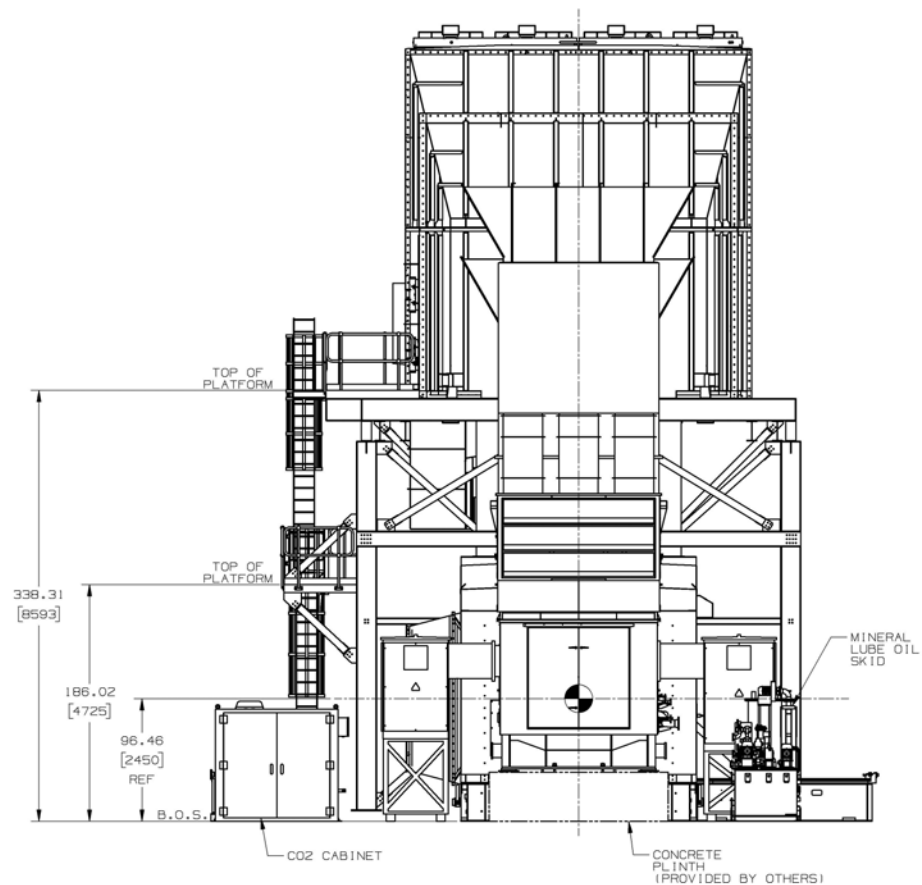
GENERAL ARRANGEMENT  
TRENT 60 WLE  
SCALE: NTS  
REV 1



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FRONT ELEVATION  
ISI PUMP SKID  
NOT SHOWN



BACK ELEVATION

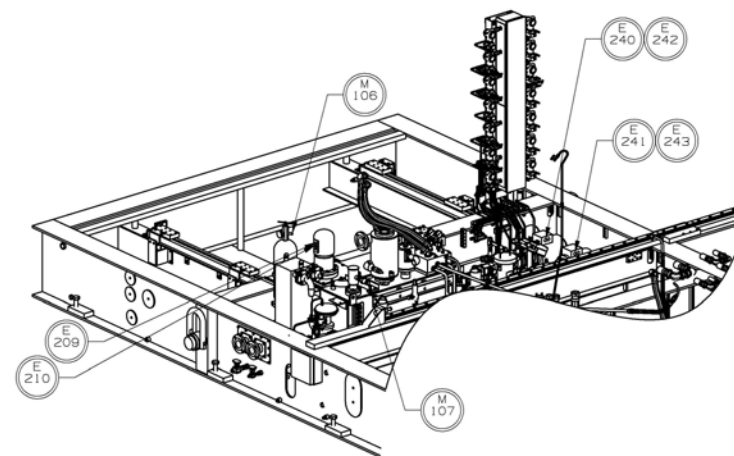
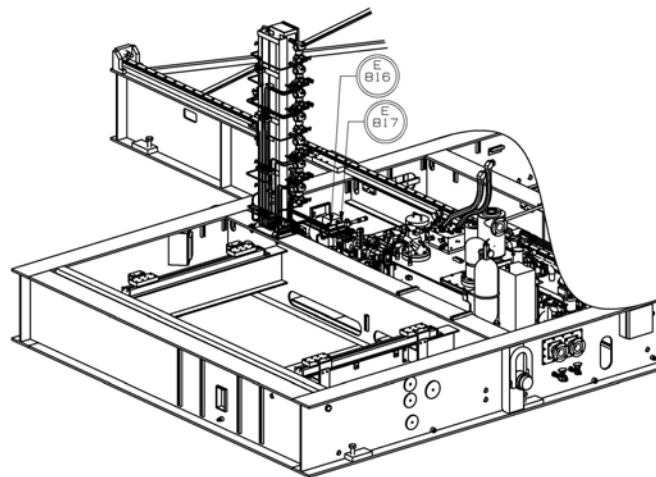
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3RD ANGLE PROJECTION  
ENGR. 24  
ENGR. UJ SL-P  
ENGR. BY1 SH  
CHKD. BY1 KMD  
DRWN BY1 ACK  
DRG. DATE1 02/20/09

40157-01.102 UPDATED VIEW, ADDED INCH DIMENSIONS, WAS SHEET 9	OSMARIO ADK
REV NO	ECO NO / DESCRIPTION
REVISION HISTORY	
ISSUE	DATE BY
 <b>Rolls-Royce</b>	
ROLLS-ROYCE ENERGY SYSTEMS INC. ROLLS-ROYCE POWER TECHNOLOGIES, WEST GERRARD 2010 4550 US	
GENERAL ARRANGEMENT TRENT 60 WLE	
SIZE A1	REV 1
SCALE: NTS	

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UNIGRAPHICS  
DRAWING

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# INTERNAL VIEWS OF GAS TURBINE LUBE OIL ENCLOSURE REMOVED FOR CLARITY

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3RD ANGLE PROJECTION

ENGR. ZH  
ENGR. UJ SL-P  
ENGR. BYI SH  
CHKD. BYI KMD  
DRAWN BYI ACK  
DRG. DATE: 02/20/09

1	40157.01.T02 WAS SHEET 10	OSMARIO ADK
REV NO	ECO NO / DESCRIPTION	DATE
	REVISION HISTORY	BY
ISSUE		



GENERAL ARRANGEMENT  
TRENT 60 WLE

SCALE: NTS	REV 1
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UNIGRAPHICS  
DRAWING

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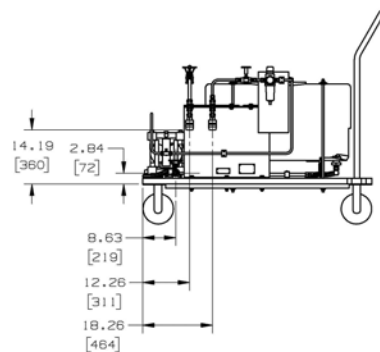
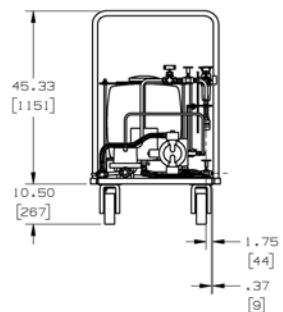
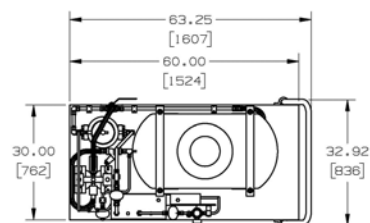
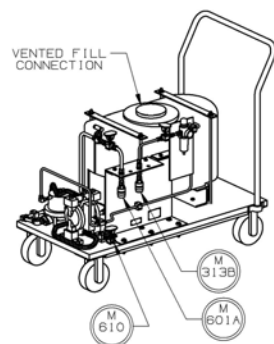
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## ©CUSTOMER CONNECTIONS

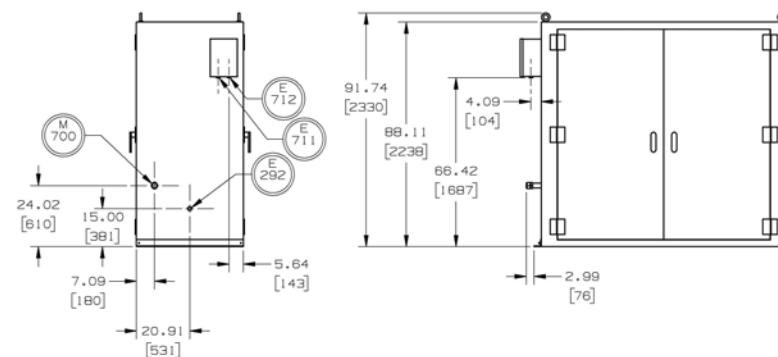
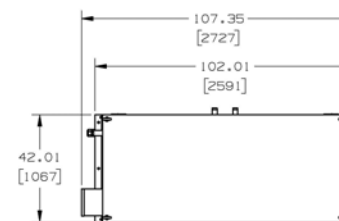
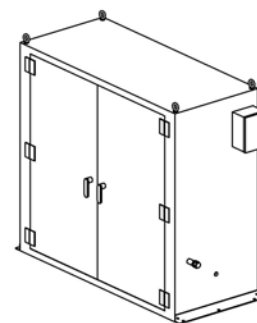
CNTN	SIZE	TYPE	SERVICE
M313B	0.75"	QUICK CONNECT	INSTRUMENT AIR SUPPLY
M601A	0.75"	QUICK CONNECT	SOAKWASH SUPPLY FROM WASH CART
M610	0.50"	NPT (F)	WASH TANK DRAIN



WASH TANK AND CART

## ©CUSTOMER CONNECTIONS

CNTN	SIZE	TYPE	SERVICE
E292	0.75"	NPT	CO2 CABINET HEATER
E711	UNDRIILLED GLAND PLATE		COMMUNICATION SIGNALS AND POWER FROM FPPT-1 TO FPPT-3
E712	UNDRIILLED GLAND PLATE		COMMUNICATION SIGNALS AND POWER FROM FPPT-3 TO UCP
M700	1.50"	OD TUBE	CO2 LINE AT CABINET



CO2 CABINET

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ENGR. 24  
ENGR. UJ SL-P  
ENGR. BYI SH  
CHKD. BYI KMD  
DRAWN BYI ACK  
DRG. DATE1 02/20/09

REV NO	ECO NO / DESCRIPTION	DATE
ISSUE	REVISION HISTORY	BY



Rolls-Royce

ROLLS-ROYCE ENERGY SYSTEMS, INC. ROLLS-ROYCE POWER TECHNOLOGIES, INC. (U.S. COMPANY) C/O ROLLS-ROYCE ENERGY SYSTEMS, INC.

GENERAL ARRANGEMENT  
TRENT 60 WLE

SIZE	A1	REV	1
SCALE	1 NTS		

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UNIGRAPHICS  
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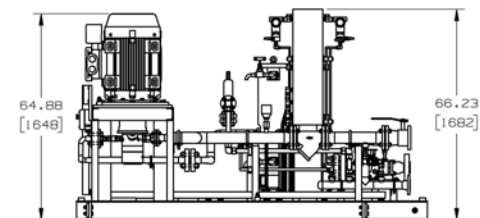
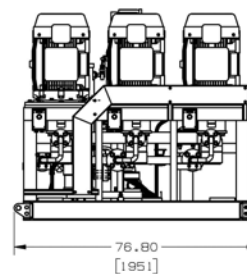
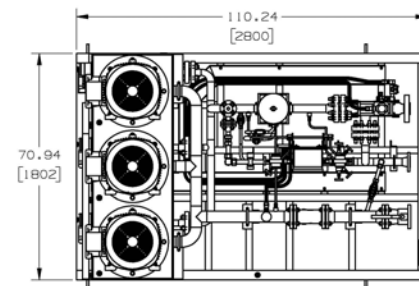
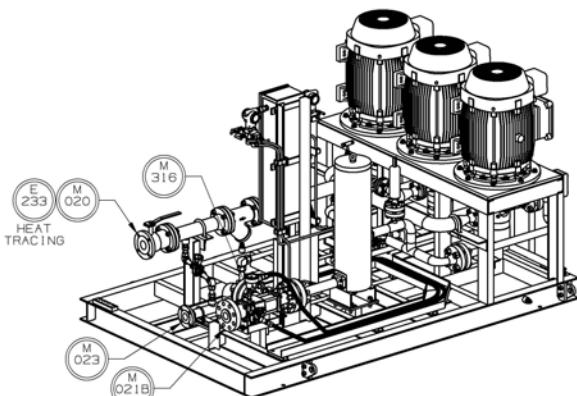
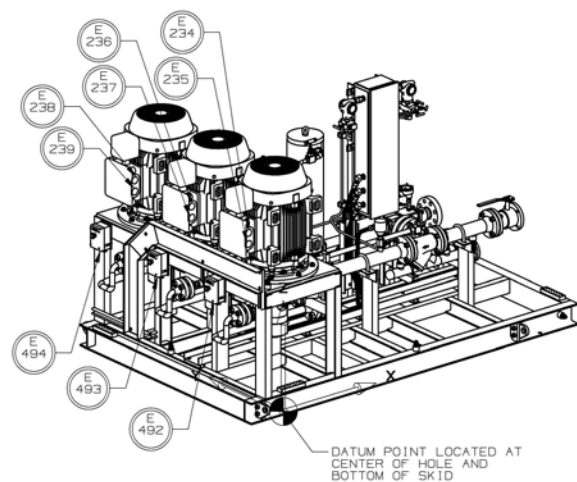
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# ⊙ ELECTRICAL CUSTOMER CONNECTIONS

CNTN	SIZE	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
E233	0.75"	NPT	POWER SUPPLY, HEAT TRACING	60.87	36.81	29.88	1546	935	759
E234	3.00"	NPT(F)	WATER INJECTION PUMP MOTOR #1 POWER	-6.85	5.91	50.55	-174	150	1284
E235	0.75"	NPT(F)	WATER INJECTION PUMP MOTOR #1 ANTI-CONDENSATION HEATER	-6.85	5.91	47.40	-174	150	1204
E236	3.00"	NPT(F)	WATER INJECTION PUMP MOTOR #2 POWER	-6.85	29.53	50.55	-174	750	1284
E237	0.75"	NPT(F)	WATER INJECTION PUMP MOTOR #2 ANTI-CONDENSATION HEATER	-6.85	29.53	47.40	-174	750	1204
E238	3.00"	NPT(F)	WATER INJECTION PUMP MOTOR #3 POWER	-6.85	53.15	50.55	-174	1350	1284
E239	0.75"	NPT(F)	WATER INJECTION PUMP MOTOR #3 ANTI-CONDENSATION HEATER	-6.85	53.15	47.40	-174	1350	1204
E492	0.50"	NPT(F)	WATER INJECTION MOTOR #1 STOP PUSH BUTTON	-8.35	63.90	27.56	-212	1623	700
E493	0.50"	NPT(F)	WATER INJECTION MOTOR #2 STOP PUSH BUTTON	-8.35	40.28	27.56	-212	1023	700
E494	0.50"	NPT(F)	WATER INJECTION MOTOR #3 STOP PUSH BUTTON	-8.35	16.65	27.56	-212	423	700

# ⊙ MECHANICAL CUSTOMER CONNECTIONS

CNTN	SIZE	CLASS (RATING)	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
M020	3.00"	150#	RF	DEMINERALIZED WATER INLET - (AT SKID)	93.19	18.50	25.83	2367	470	656
M021B	2.00"	1500#	RF	DEMINERALIZED WATER SUPPLY - (AT SKID)	92.95	52.36	16.46	2361	1330	418
M023	2.00"	150#	RF	DEMINERALIZED WATER RETURN	92.95	35.59	10.94	2361	904	278
M316	0.50"		NPT(F)	INSTRUMENT AIR SUPPLY - WATER INJECTION SKID	87.32	59.84	16.50	2218	1520	419



## WATER INJECTION SKID

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3RD ANGLE PROJECTION  
ENGR. 24  
ENGR. 11 SL-17  
ENGR. 011 SH  
CHKD. BY KMD  
DRAWN BY ACK  
DRG. DATE: 02/20/09

40157-01-102 UPDATED VIEW  
SHEET 13  
REV NO ECO NO / DESCRIPTION  
ISSUE REVISION HISTORY



**Rolls-Royce**

GENERAL ARRANGEMENT  
TRENT 60 WLE

SCALE: NTS  
REV 1

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UNIGRAPHICS  
DRAWING

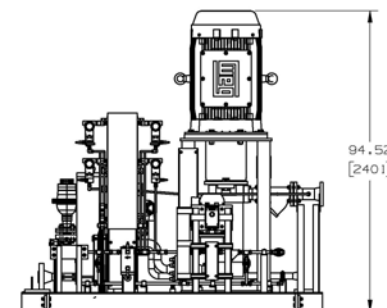
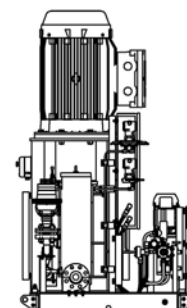
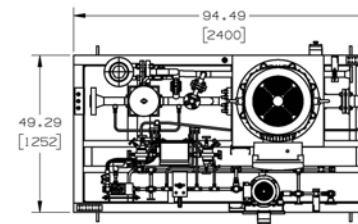
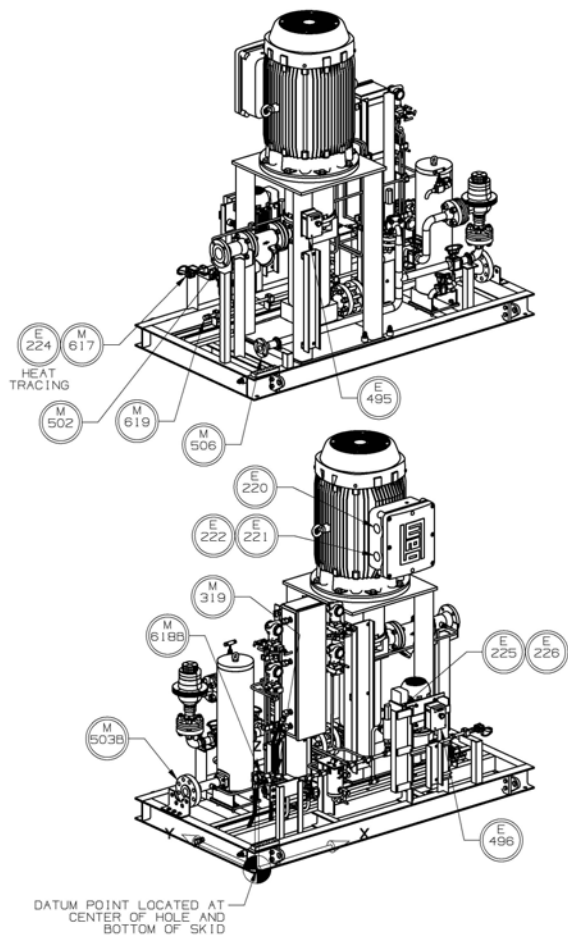
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MECHANICAL CUSTOMER CONNECTIONS

CNTN	SIZE	CLASS (RATING)	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
M319	0.50"		NPT(F)	INSTRUMENT AIR SUPPLY	12.17	6.65	23.23	309	169	590
M502	3.00"	150#	RF	LIQUID FUEL SUPPLY TO FUEL FORWARDING SKID	92.72	33.66	36.93	2355	855	938
M503B	2.00"	900#	RF	LIQUID FUEL SUPPLY FROM FUEL FORWARDING SKID	3.15	33.66	10.87	80	855	276
M506	1.50"	150#	RF	LIQUID FUEL RETURN	85.63	42.13	11.18	2175	1070	284
M617	0.50"		NPT(F)	WATER FLUSH SKID DEMINERALIZED WATER SUPPLY	80.08	4.69	18.62	2034	119	473
M618B	0.50"		NPT(F)	WATER FLUSH SUPPLY FROM FUEL FORWARDING/WATER FLUSH SKID	7.17	6.14	18.70	182	156	475
M619	1.00"		NPT(F)	WATER FLUSH SKID DEMINERALIZED WATER RETURN	80.12	12.20	8.82	2035	310	224

ELECTRICAL CUSTOMER CONNECTIONS

CNTN	SIZE	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
E220	2x3.00"	NPT(F)	LIQUID FUEL PUMP MOTOR POWER	54.61	17.36	77.13	1387	441	1959
E221	0.75"	NPT(F)	LIQUID FUEL PUMP MOTOR ANTI-CONDENSATION HEATER	54.61	17.36	69.25	1387	441	1759
E222	0.75"	NPT(F)	LIQUID FUEL PUMP MOTOR THERMISTOR	54.61	17.36	69.25	1387	441	1759
E224	0.75"	NPT	POWER SUPPLY, HEAT TRACING	52.83	5.55	27.17	1342	141	690
E225	1.00"	NPT(F)	WATER FLUSH PUMP MOTOR POWER	52.83	5.55	27.17	1342	141	690
E226	0.75"	NPT(F)	WATER FLUSH PUMP MOTOR ANTI-CONDENSATION HEATER	52.83	5.55	27.17	1342	141	690
E495	0.50"	NPT(F)	LIQUID FUEL PUMP MOTOR STOP PUSH BUTTON	73.19	48.86	41.46	1859	1241	1053
E496	0.50"	NPT(F)	WATER FLUSH PUMP MOTOR STOP PUSH BUTTON	58.70	-2.36	25.71	1491	-60	653



LIQUID FUEL FORWARDING SKID

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3RD ANGLE PROJECTION  
ENGR. 24  
ENGR. 11 SL-7  
ENGR. 201 SH  
CHKD. BY KMD  
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DATE: 02/20/09

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1	40157-01-102 UPDATED VIEW, ADDED INCH DIMENSIONS, WAS SHEET 14	02/20/09

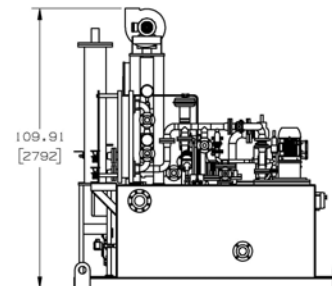
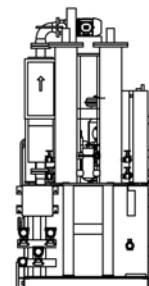
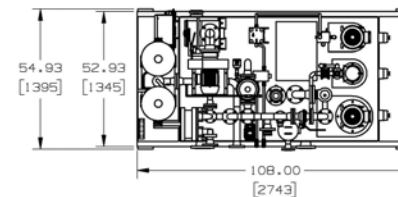
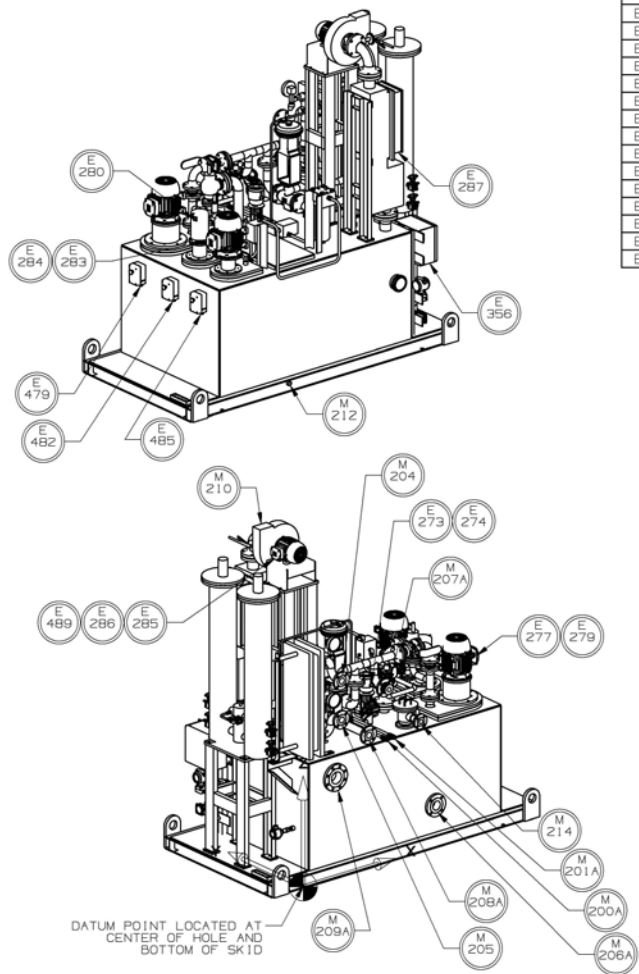


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GENERAL ARRANGEMENT TRENT 60 WLE			

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DRAWING

© MECHANICAL CUSTOMER CONNECTIONS										
CNTN	SIZE	CLASS (RATING)	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
M200A	0.75"		OD TUBE	JACKING OIL SUPPLY TO AC GENERATOR	33.43	-1.10	41.54	849	-28	1055
M201A	0.75"		OD TUBE	JACKING OIL SUPPLY TO AC GENERATOR	36.38	-1.10	41.54	924	-28	1055
M204	2.00"	150#	RF	COOLER GLYCOL OUTLET	15.16	-0.59	65.98	385	-15	1676
M205	2.00"	150#	RF	COOLER GLYCOL INLET	15.16	-0.59	52.80	385	-15	1341
M206A	2.00"	150#	RF	MAIN PUMP SUCTION	52.68	-1.61	14.49	1338	-41	368
M207A	1.25"	150#	RF	MAIN PUMP DISCHARGE	37.68	3.58	56.02	957	91	1423
M208A	1.50"	150#	RF	MINERAL LUBE OIL SUPPLY	25.67	-1.26	45.16	652	-32	1147
M209A	5.00"	150#	RF	MINERAL LUBE OIL RETURN	12.20	-1.61	34.21	310	-41	869
M210	-			BLOWER VENT	9.37	31.46	109.92	238	799	2792
M212	0.75"		NPT	RESERVOIR TANK DRAIN	53.35	50.91	2.09	1355	1293	53
M214	1.50"	150#	RF	RESERVOIR TANK FILL	45.79	-2.32	44.92	1163	-59	1141

ELECTRICAL CUSTOMER CONNECTIONS									
CNTN	SIZE	TYPE	SERVICE	X INCH	Y INCH	Z INCH	X MM	Y MM	Z MM
E273	0.75"	NPT(F)	MINERAL LUBE OIL RESERVOIR HEATER	39.80	17.05	52.64	1011	433	1337
E274	0.75"	NPT(F)	MINERAL LUBE OIL RESERVOIR TEMPERATURE SWITCH	39.80	17.05	52.64	1011	433	1337
E277	1.00"	NPT(F)	MINERAL LUBE OIL AUXILIARY PUMP MOTOR	76.57	8.66	55.28	1945	220	1404
E279	0.50"	NPT(F)	MINERAL LUBE OIL AUXILIARY PUMP MOTOR ANTI-CONDENSATION HEATER	76.57	8.66	55.28	1945	220	1404
E280	0.50"	NPT(F)	MINERAL LUBE OIL DC PUMP MOTOR	73.78	28.82	56.18	1874	732	1427
E283	1.00"	NPT(F)	JACKING OIL PUMP MOTOR	76.57	39.65	53.27	1945	1007	1353
E284	0.50"	NPT(F)	JACKING OIL PUMP MOTOR ANTI-CONDENSATION HEATER	76.57	39.65	53.27	1945	1007	1353
E285	0.75"	NPT(F)	DEMISTER BLOWER MOTOR ANTI-CONDENSATION HEATER	10.31	25.59	100.71	262	650	2558
E286	0.75"	NPT(F)	DEMISTER BLOWER MOTOR	10.31	25.59	100.71	262	650	2558
E287	0.75"	NPT(F)	DEMISTER POWER SUPPLY	8.15	43.46	67.91	207	1104	1725
E356	UNDRILLED	GLAND PLATE	MINERAL LUBE OIL CONSOLE INTERCONNECT SIGNALS	-2.56	44.76	28.27	-65	1137	718
E479	0.75"	NPT(F)	MINERAL LUBE OIL AUXILIARY PUMP MOTOR STOP PUSHBUTTON	82.24	12.36	30.47	2089	314	774
E482	0.75"	NPT(F)	MINERAL LUBE OIL DC PUMP MOTOR STOP PUSHBUTTON	82.24	28.82	30.47	2089	732	774
E485	0.75"	NPT(F)	JACKING OIL PUMP MOTOR STOP PUSHBUTTON	82.24	42.76	30.47	2089	1086	774
E489	0.75"	NPT(F)	DEMISTER BLOWER MOTOR STOP PUSHBUTTON	10.31	25.59	100.71	262	650	2558



MINERAL LUBE OIL SKID

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ENGR. BFI SH  
CHKD. BFI KMC  
DRAWN BFI ACK  
DRW. DATE: 02/20/09

40157-01-102 UPDATED VIEW AND CONNECTION TABLE PER CURRENT INFORMATION. ADDED INCH DIMENSIONS. WAS SHEET 15	OSMARIO ADK	
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GENERAL ARRANGEMENT TRENT 60 WLE		
SCALE: NTS		REV 1





# Rolls-Royce

## Global Engineering Reference

## GER 0070

Revision: 2

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### Grounding / Earthing Design and Application

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## EXECUTIVE SUMMARY

Grounding /earthing encompasses several different but interrelated aspects of electrical and instrumentation system design and construction, all of which are essential to the safety and proper operation of the system and the equipment supplied by it. This document defines the parts of a grounding system (bonding and grounding electrodes) and how they are to be applied to Rolls-Royce Energy Products. This includes the three types of bonding often required and the fact that only one grounding electrode system should be in place.

**NOTE: The actual design of a grounding system or grounding grid network should be done by a qualified Electrical Engineer.**

## POINT OF EMBODIMENT

Applies to all new equipment tenders, initiated after issue of this revision, it should not be applied retrospectively to production or legacy projects unless affected equipment overhaul or replacement is required.

Revision History			
Revision	Revision Description	Author	Approval Signature, Date
0	Initial Issue	DMHauck	P. Rainer 17 Jul 05
1	Reorganized and updated, Change Section 3	P. Wakefield /DMH	P. Rainer 06 Feb 06
2	Edit nested standards as per ECR 30836	B. Hayman	



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## TABLE OF CONTENTS

<b>1</b>	<b>SCOPE.....</b>	<b>5</b>
<b>2</b>	<b>REFERENCE DOCUMENTS AND SPECIFICATIONS .....</b>	<b>5</b>
<b>3</b>	<b>DEFINITIONS .....</b>	<b>5</b>
3.1	Bonding.....	5
3.2	Ground .....	5
3.3	Grounding Conductor .....	6
3.4	Neutral Conductor.....	6
3.5	Ground Electrode.....	6
3.6	Grounding Electrode System.....	6
3.7	Equipment Grounding Conductor .....	6
3.8	Safety Ground.....	6
3.9	Instrument Ground.....	6
3.10	Intrinsic Safety Ground .....	6
3.11	Single Point or “Star” Ground .....	6
3.12	Multi-Point Ground.....	6
3.13	Electromagnetic Compatibility (EMC).....	6
<b>4</b>	<b>THE PURPOSE OF GROUNDS.....</b>	<b>7</b>
4.2	Safety.....	7
4.3	Noise Reduction .....	7
<b>5</b>	<b>DESCRIPTION OF A GROUNDING SYSTEM .....</b>	<b>7</b>
5.2	The Grounding Electrode System .....	7
5.3	The Bonding System .....	8
<b>6</b>	<b>REQUIREMENTS FOR EQUIPMENT (SAFETY) GROUNDING.....</b>	<b>8</b>
<b>7</b>	<b>REQUIREMENTS FOR INSTRUMENT (CLEAN) GROUND.....</b>	<b>8</b>
<b>8</b>	<b>REQUIREMENTS FOR INTRINSICALLY SAFE (IS) GROUND .....</b>	<b>9</b>
<b>9</b>	<b>SPECIFIC BONDING REQUIREMENTS .....</b>	<b>9</b>
<b>10</b>	<b>SPECIAL CASE BONDING—ELECTRIC MOTOR DRIVES.....</b>	<b>11</b>
<b>11</b>	<b>STATIC BUILD UP PROTECTION .....</b>	<b>11</b>
<b>12</b>	<b>LIGHTNING PROTECTION BONDING .....</b>	<b>12</b>



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<b>13</b>	<b>SYMBOLS (PER IEEE/ANSI 315)</b>	<b>14</b>
13.1	Symbol for “safety” or “dirty” ground	14
13.2	Symbol for “instrument” or “clean” ground	14
13.3	Symbol for a “Special purpose” ground. Rolls-Royce Energy uses it to signify “intrinsically safe” or (IS) ground.	14
<b>14</b>	<b>DETAILS OF GROUNDING/EARTHING ASSEMBLIES</b>	<b>15</b>
14.1	DETAIL A – TYPICAL GROUND/EARTH STRAP CONNECTION	15
14.2	TYPICAL JUNCTION BOX GROUNDING/EARTHING DETAIL	16
14.3	TYPICAL CABLE TRAY GROUNDING/EARTHING	17
14.4	TYPICAL SINGLE AND MULTIPLE POINT GROUND/EARTH CONNECTIONS	18
14.5	TYPICAL GROUND/EARTH BOSS ASSEMBLY AND LOCAL BONDING	19
14.6	GROUNDING/EARTHING OF MOTORS AND HEATERS	20



## 1 SCOPE

1.1 This document covers the parts of and the requirements for the grounding systems to be used on Rolls-Royce Energy Equipment and some standards on how to apply them.

**NOTE: This document is an Engineering Standard. No deviations are permitted to instructions or specifications herein other than those approved in writing by the PCB (Product Change Board).**

1.2 All local codes with respect to electrical safety and grounding that apply must be followed. In the case of conflict, the Local Codes and Regulations must be followed. If doing so would create an unsafe condition, the issue needs to be taken up with the local authority.

1.3 Pipelines and offshore installations may have some type of cathodic protection system installed. It is best to discuss with Customer how the grounding is to be done.

## 2 REFERENCE DOCUMENTS AND SPECIFICATIONS

- 2.1 ANSI/NFPA 75 - Standard for the Protection of Information Technology Equipment
- 2.2 ANSI/NFPA 780 - Standard for the Installation of Lightning Protection Systems
- 2.3 CSA C22.2 - Canadian Electric Code (CEC)
- 2.4 2004/108/ EC Electromagnetic Compatibility Directive
- 2.5 IEEE/ANSI 315 - Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Class Designation Letters)
- 2.6 IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment
- 2.7 NFPA 70 - National Electric Code (NEC)
- 2.8 52048AAC – Lub - Ground
- 2.9 52048AAD - Plate - Grounding
- 2.10 52048AAF – Block - Grounding

## 3 DEFINITIONS

### 3.1 Bonding

3.1.1 The electrical interconnecting of conductive parts designed to maintain a common potential.

3.1.2 The permanent joining of metallic parts to form an electrically conductive path, which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

### 3.2 Ground

3.2.1 A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to earth. Grounds are not current return paths and should not carry significant current except under fault conditions.



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### **3.3 Grounding Conductor**

3.3.1 The connection between the grounding electrode and the device to be grounded. It is the device by which “bonding” is accomplished.

### **3.4 Neutral Conductor**

2.4.1 The current return path for a grounded electrical distribution system. It is also tied to the grounding electrode system but it is not a ground.

### **3.5 Ground Electrode**

3.5.1 A conductor or group of conductors in intimate contact with the earth for the purpose of providing a connection with ground.

### **3.6 Grounding Electrode System**

3.6.1 The collection of all the grounding electrodes bonded together.

### **3.7 Equipment Grounding Conductor**

3.7.1 The conductor used to connect noncurrent carrying exposed metal to the “grounding electrode system.”

### **3.8 Safety Ground**

3.8.1 Also referred to as “dirty” ground. It is the system of bonding for non-sensitive equipment to the grounding electrode system.

### **3.9 Instrument Ground**

3.9.1 More commonly referred to as “clean” ground. It is the bonding system for equipment that is sensitive to noise (such as thermocouples, RTD's, current loops etc.).

### **3.10 Intrinsic Safety Ground**

3.10.1 The bonding system for Zener Type Intrinsic (IS) Barriers.

### **3.11 Single Point or “Star” Ground**

3.11.1 A bonding conductor system by which separate electrical circuits are connected to the grounding electrode system at a one point.

### **3.12 Multi-Point Ground**

3.12.1 A bonding system where more than one tie is present between a particular piece of equipment and the grounding electrode system.

### **3.13 Electromagnetic Compatibility (EMC)**

3.13.1 The ability of a system to resist influence from and not create significant external magnetic, electric, and electromagnetic fields. This is codified in the European Union by the (EMC) Directive 2004/108/ EC.



## **4 THE PURPOSE OF GROUNDS**

4.1 Grounds serve two (2) different purposes, safety and noise reduction.

### **4.2 Safety**

4.2.1 There are two primary methods that grounding promotes safety. These are (1) preventing potential differences between parts and (2) providing a current path to operate circuit protection devices.

4.2.2 Equipment grounding/earthing, also known as mechanical or safety grounding / earthing, is essential to the safety of personnel. Its function is to ensure that all exposed noncurrent-carrying metallic parts of all structures and equipment are at the same potential. That is the zero reference potential of the Equipment grounding earth. This allows a person to touch a device (not including current carrying devices) and not get shocked (current carrying devices are insulated to prevent shocks). Grounding /earthing is required by the National Electrical Code (NEC) (Article 250), the National Electrical Safety Code (NESC) and the International Electrotechnical Commission (IEC) among others.

4.2.3 Equipment grounding / earthing also provides a return path for ground fault currents, permitting protective devices to operate effectively. Bonding conductors must be sized such that current flow from accidental grounding of an energized part of the system cannot generate sufficient heat to start a fire before the protective devices operate.

### **4.3 Noise Reduction**

4.3.1 The ground is a “zero potential” reference and as such can redirect noise to earth rather than allowing it to couple into the system. Providing very low impedance to earth, can help meet EMC targets such as the “EMC Directive” and, more importantly, maintain proper operation of sensitive equipment.

## **5 DESCRIPTION OF A GROUNDING SYSTEM**

5.1 Grounding systems consist of two main parts, the grounding electrode system and the bonding system.

### **5.2 The Grounding Electrode System**

5.2.1 This is the actual physical contact to the earth “some large conducting body that serves the place of earth” (such as an off shore platform grounding system). The grounding electrode system needs to have sufficiently low resistance so that someone coming in contact with the ground will not have a significant potential difference themselves and the bonding system.

5.2.2 There should be only one grounding electrode system for a building. Multiple grounding electrodes may be used but they must all be tied into one grounding electrode system. (NEC section 250.50).

5.2.3 System grounding / earthing systems of less than 1 ohm may be obtained by the use of a number of individual electrodes connected together. Such a low resistance may only be required for large substations or generating stations. Resistances in the 2 – 5 ohm range are generally found to be suitable for industrial plant substations and buildings and large commercial installations.

5.2.4 Grounding electrode system impedance should be tested with a “fall-of-potential” method instrument. Rolls-Royce Energy requires a maximum of 5 ohms of impedance to ground.



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5.2.5 The preferred grounding electrode system for on shore systems is a ground grid system with grounding electrodes at the corners.

### 5.3 The Bonding System

5.3.1 This is the conducting tie between all the parts to be grounded on the grounding electrode system.

5.3.2 A bonding system needs to be able to handle any fault current likely to be impressed on it. For example, if a motor has a 30 amp feed and the winding happens to short to the case, its bond must be able to conduct the fault current sufficiently to operate the fuses or breakers. It also must have sufficiently low impedance to not generate significant potential differences to earth.

5.3.3 A bonding system can be a “star” or a “multi-point” configuration. “Star” systems are typically for low noise grounds (such as for grounding shielding) and “Multipoint grounds” are much easier to install for safety bonding.

## 6 REQUIREMENTS FOR EQUIPMENT (SAFETY) GROUNDING

6.1 The ground conductor provides a return path for the ground fault currents. It must:

6.1.1 Be of sufficiently low impedance to prevent unsafe voltage drops. That is voltage rise due to  $I \times Z$  (maximum expected fault current x impedance) drops.

6.1.2 Be large enough to carry the maximum ground fault current for sufficient time without damage to allow protective devices (ground fault relays, circuit breakers, fuses) to operate. Table 1. NEC Table 250.122: Minimum Size of Equipment Grounding Conductors for Grounding Raceways and Equipment.

**NOTE: The grounded conductor of the system (usually the neutral conductor), although grounded at the source, must not be used for equipment grounding.**

6.2 The equipment-grounding conductor may be the metallic conduit or raceway of the wiring system. It can also be a separate equipment-grounding conductor run with the circuit conductors.

6.3 If a separate equipment-grounding conductor is used, it may be bare or insulated. If the wire is insulated then insulation colors must be green with a yellow stripe. Conductors with green insulation may not be used for any purpose other than for grounding.

6.4 Where conductors are run in parallel in multiple raceways or cables, the equipment grounding conductor, where used, shall be run in parallel. Each parallel grounding conductor shall be sized accordingly but under no circumstances shall the conductor size be smaller than the largest current carrying conductor attached to the equipment. Table 1. NEC Table 250.122: Minimum Size of Equipment Grounding Conductors for Grounding Raceways and Equipment.

6.5 The equipment grounding system must be bonded to a grounding electrode system at the source or service (the shop grounding system is an example); however, it may also be connected to ground at many other points. This will not hinder the safe operation of the electrical distribution system.

## 7 REQUIREMENTS FOR INSTRUMENT (CLEAN) GROUND

7.1 Inputs to electronic measurement and instrumentation equipment often are noise sensitive devices (such as thermocouples, RTD's, Current loops, certain electronic controls, etc.) and require special handling of their shield and signal grounds.



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7.2 Clean grounds should be tied via a separate bonding system even though this ground must be tied to the same grounding electrode system as all other grounds.

7.3 Instrument ground bonding should use a "star" grounding system whenever possible. When it is not practical to run separate bonding conductors, they should have large surface areas since high frequency noise travels in the surface of conductors (skin effect) and to minimize conducted coupling of noise.

7.4 Instrument bonding wires are indicated by solid green insulation of the wire.

## **8 REQUIREMENTS FOR INTRINSICALLY SAFE (IS) GROUND**

8.1 Zener barriers must be connected to ground for safety. There are many ways that this can be accomplished. Local and/or National codes must be followed. The following items are typical of these codes.

8.1.1 The barrier's grounding terminal(s) must be connected, using the shortest route possible, to the grounding electrode system. For example, the CEC requires that this connection to have a resistance of less than one (1) ohm.

8.1.2 The conductors should (must in Canada) be isolated from ground at all places except to the point of connection.

8.1.3 The use of two (2) separate conductors (No. 12 AWG at a minimum) for grounding the barriers is highly recommended (CEC). Two conductors are also preferred by the IEC as well, but a single conductor of at least 4 mm<sup>2</sup> is allowed.

8.1.4 The grounding conductor(s) used for the intrinsically safe barriers must be directly connected to the grounding electrode and not connected to any other safety or control grounding conductor.

8.2 The Rolls-Royce Energy standard for IS bonding wires is solid green wire insulation with a label that identifies it as an "IS" ground.

## **9 SPECIFIC BONDING REQUIREMENTS**

9.1 All conductive objects and devices mounted on or adjacent to the skid package must be bonded to ground / earth. System bonding to "dirty ground", shall consist of grounding / earthing the skids, Silencer / Plenum, Ventilation Ductwork, Turbine / Generator / Compressor enclosures, Gearboxes, Tanks and Vessels, Fabricated Units, Instrument Systems, Fire and Gas System, and any other equipment attached to the main or auxiliary skids.

9.2 The Main Skids, Silencer / Plenum and any separate auxiliary equipment that is mounted on a skid shall each be fitted with welded grounding / earthing bosses (See Section 14.5 Typical Ground/Earth Boss Assembly And Local Bonding) on two (2) diagonal corners for the customer connection. These bosses are per drawing 52048AAD.

9.3 The ventilation ductwork shall be bonded across each seam with a bonding jumper that is no smaller than 16mm<sup>2</sup> (#6 AWG). The supporting structure shall have a single point ground boss welded in a location to allow easy connection to the grounding system. The ductwork and the support structure shall be bonded together using either the multi-point grounding plate or single point ground bosses (See Section 14.4 Typical Single And Multiple Point Ground/Earth Connections and Section 14.5 Typical Ground/Earth Boss Assembly And Local Bonding drawing 52048AAF and 52048AAC).



9.4 The Turbine / Generator / Compressor enclosures shall have a bonding jumper (16mm<sup>2</sup>)(#6 AWG) across each vertical seam and the base of the enclosure shall be bonded to the skid base either with a bonding jumper across the seam between the enclosure flange and the skid or by a dedicated grounding / earthing bolt tapped into the skid base and painted green or otherwise indicated to be a grounding / earthing point. (See 14.1 DETAIL A – TYPICAL GROUND/EARTH STRAP CONNECTION) The grounding / earthing bolts shall be placed at each vertical split in the enclosure.

9.5 Tank and vessel grounding / earthing shall be provided by bosses or approved lugs.

9.6 Electrical continuity between metallic enclosures and conduit, armor or cable sheaths and armor, or across any joints in the conduit or armor should be maintained by the integrity of the joint itself. If external bonding is necessary, it should be connected directly across the joint.

9.6.1 All metallic junction boxes shall be grounded / earthed from the stud mounted on the box to the nearest grounding / earthing block attached to the skid. Each cable gland shall have a serrated washer between the gland plate inner face and the gland locknut. Gland plates shall be supplied with grounding / earthing studs and the gland plate grounding / earthing studs shall be connected internally to the junction box grounding / earthing stud.

9.6.2 Where this grounding / earthing scheme is not possible, one gland on each gland plate (preferable the largest gland) shall have a grounding / earthing tag installed between the gland and the sealing washer. All of the grounding / earthing tags shall be linked with a grounding / earthing wire and the last gland in this “daisy chain” shall be run to the junction box grounding / earthing stud.

9.6.3 If the junction box is serving as a power connection, the grounding / earthing conductor shall be sized in relation to the size of the feeder cable but in no case should the grounding / earthing wire be smaller than 16mm<sup>2</sup> (#6 AWG). (See Table 1).

9.7 All instruments, fire and gas devices (including the discharge nozzles), start/stop pushbuttons (motors), that have a metallic housing shall be grounded / earthed either by means of a drilled and tapped hole or a grounding / earthing wire attached to the housing and then connected to the nearest grounding / earthing block attached to the skid. Alternatively, instruments with metallic housing and external grounding / earthing studs may be connected directly to the grounding / earthing block with a properly sized grounding / earthing wire. (See Table 1).

9.7.1 If a device is mounted on channels (Leprack, Unistrut or equal), all of the attachments between the channel and the grounded / earthed steelwork must incorporate serrated washers.

9.8 All metallic cable support systems shall be effectively grounded / earthed. Where cable support systems are not installed in an electrically continuous run, a bonding conductor shall be installed to ensure electrical continuity. Serrated washers are to be installed at each cable tray joint to maintain continuity. Both ends of the cable tray run are to be connected to the nearest grounding / earthing point on the structure. For sizing of conductor, please see Table 1.

9.9 Motors and / or heater enclosures shall be grounded / earthed through a drilled and tapped hole in either the body or foot of the motor. The grounding / earthing lead shall be connected using a serrated washer and the lead shall be run to the nearest grounding / earthing block attached to the skid.

9.10 All door mounted equipment on panels or switch units shall be bonded to the main body of it's respective housing or enclosure by means of a flexible grounding / earthing conductor (per Table 1) which shall be looped across any door hinges to preserve the continuity. Braided wire (such as assembly ZG50280-423#1) is a good choice because of its flexibility and large surface area (for low impedance at high frequencies).



9.11 Bolts connecting pipe flanges and ducts should provide sufficient leakage path for any build up of static electricity. Where good electrical contact might be jeopardized by paint or preservatives, the effective grounding / earthing shall be achieved by the addition of grounding / earthing continuity links across such joints.

9.12 All pipes and ductwork shall be bonded to the adjacent steel structures at all bulkhead penetrations using a grounding / earthing lead attached to a drilled and tapped hole and a serrated washer to cut through the coating. The exception to this is underground gas piping. It is typically isolated and has its own grounding and/or cathodic protection system. See NEC Section 250.104.

## **10 SPECIAL CASE BONDING—ELECTRIC MOTOR DRIVES**

10.1 Due to the very noisy nature of digital variable speed and servo motor drives, they should have a separate bonding conductor all the way to the grounding electrode system. As such they would be green with a yellow stripe and indicate it as a direct ground.

10.2 Due to induced currents in the motor case, a solid bond needs to be made between the motor and the motor drive unit. It is recommended that the power to the motor be shielded and that the shield be tied both to the motor and the motor drive return. This is in addition to the neutral wire to the motor that must handle the motor fault current. Avoid splicing variable speed motor power cables when ever possible. It is best to have a continuous run between the drive and motor. The best method of maintaining the integrity of the necessary high frequency bonding is to use a shielded connector. Splicing can also be accomplished using a grounded and shielded junction box. Please follow the following guidelines when installing a junction box:

10.2.1 The shields should run through without being tied to the junction box.

10.2.2 Separate junction boxes for power and feedback are required.

10.2.3 Be sure to follow the manufacturer's installation guidelines.

## **11 STATIC BUILD UP PROTECTION**

11.1 The most common experiences of static electricity are the crackling and clinging of fabrics as they are removed from clothes dryer or the electric shock felt as one touches a metal object after walking across a carpeted floor or stepping out of an automobile. Nearly everyone recognizes that these phenomena occur mainly when the atmosphere is very dry, particularly in winter. To most people, they are simply an annoyance. In many industries, particularly those where combustible materials are handled, static electricity can cause fires or explosions.

11.2 In comparatively recent times, when the properties of flowing (current) electricity were discovered, the term static came into use as a means of distinguishing a charge that was at rest from one that was in motion. However, today the term is used to describe phenomena that originate from an electric charge, regardless of whether the charge is at rest or in motion.

11.3 Fluids flowing in piping, e.g. lube oils, fuel gases, water, etc. are all capable of producing static electricity when the system is not properly mechanically grounded. This phenomenon must be considered in Rolls-Royce packages due to the flowing fluids involved.

11.4 Bonding is used to minimize the potential difference between conductive objects, even when the resulting system is not grounded. Grounding / earthing on the other hand, equalizes the potential difference between the objects and earth.



11.5 A conductive object can be grounded by a direct conductive path to the earth or by bonding it to another conductive object that is already connected to ground. Some objects are inherently grounded due to their contact with the ground. Examples of inherently grounded objects are underground metal piping or large metal storage tanks resting on the ground.

11.6 To prevent the accumulation of static electricity in conductive equipment, the total resistance of the grounding / earthing path to earth should be sufficient to dissipate charges that are otherwise likely to be present. A resistance of 1 megaohm ( $10^6$  ohms) or less is generally considered adequate. Where the grounding / earthing system is all metal, resistance in continuous grounding / earthing paths will typically be less than 10 ohms. Such systems include multiple component systems. Greater resistance usually indicates that the metal path is not continuous, usually because of loose connections or corrosion. A grounding / earthing system that is acceptable for power circuits or for lightning protection is more than adequate for static electricity grounding system.

## 12 LIGHTNING PROTECTION BONDING

12.1 The purpose of lightning protection systems are to direct lightning discharges to ground and as such they are tied to the grounding electrode system. Highly conductive paths (a very low impedance) are required so as to minimize the induced voltage.

12.2 Any lightning protection system should be bonded according to the manufacturer's recommendations and any applicable local codes.

12.3 IEEE Std 1100-1992 section 4.6.4 states:

12.3.1 Neither the NEC, ANSI/NFPA 75-1992, nor the ANSI/NFPA 780-1992 establishes impedance limits on the earth ground electrode system associated with the lightning protection system. Instead of lower resistance connections to earth, these codes favor increased frequency of bonding of the lightning conductor system to other grounded conductors within the building. This approach results in a means of reducing dangerous side-flashes, and the use of more (parallel) down-conductor paths throughout the building.

12.3.2 The idea is to have all the conductors and the ground to remain at nearly the same potential—even if the potential increases locally with respect to the “infinite ground.” This is an advantage of a ground grid or a ground ring as part of the grounding electrode system since it will act to limit potential gradients in the ground and keep the ground at the same potential as the exposed metal.

**NOTE: If the system is to be located in an area where lightning is likely, surge protection/arrestors on all non-grounded wiring/conductors entering or leaving the building is best practice to prevent personnel hazards or equipment damage. These surge arrestors should be tied to the “dirty” or “safety” ground or have their own tie to the grounding electrode system.**

12.4 When sizing the conductors for bonding of any metallic enclosure to the base structure, the possibility of a direct strike (in an outdoor installation) must be considered. In no case should the conductor be smaller than  $16 \text{ mm}^2$  (#6 AWG). See Table 1.





**Table 1. NEC Table 250.122: Minimum Size of Equipment Grounding Conductors for Grounding Raceways and Equipment**

RATING OR SETTING OF AUTOMATIC OVERCURRENT DEVICE IN THE CIRCUIT AHEAD OF THE EQUIPMENT, CONDUIT, ETC., NOT EXCEEDING (AMPERES)	Size (AWG or Kcmil or mm <sup>2</sup> )		
	Copper	Aluminum or Copper- Clad Aluminum*	Copper in mm <sup>2</sup> (Aluminum)
15	14	12	2.08 (3.31)
20	12	10	3.31 (5.26)
30	10	8	5.26 (8.36)
40	10	8	5.26 (8.36)
60	10	8	5.26 (8.36)
100	8	6	8.36 (13.29)
200	6	4	13.29 (21)
300	4	2	21 (34)
400	3	1	27 (43)
500	2	1/0	34 (54)
600	1	2/0	43 (68)
800	1/0	3/0	54 (85)
1000	2/0	4/0	68 (107)
1200	3/0	250	85 (127)
1600	4/0	350	107 (177)
2000	250	400	127 (203)
2500	350	600	177 (304)
3000	400	600	203 (304)
4000	500	800	253 (405)
5000	700	1200	355 (633)
6000	800	1200	405 (633)

**NOTE:** Where necessary to comply with Articles 250.4(A)(5) or 250.4(B)(4) of the NEC the equipment grounding conductor shall be sized larger than given in this table.

- See installation restrictions in Article 250.120 NEC



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## **13 SYMBOLS (PER IEEE/ANSI 315)**

### **13.1 Symbol for “safety” or “dirty” ground.**



### **13.2 Symbol for “instrument” or “clean” ground.**

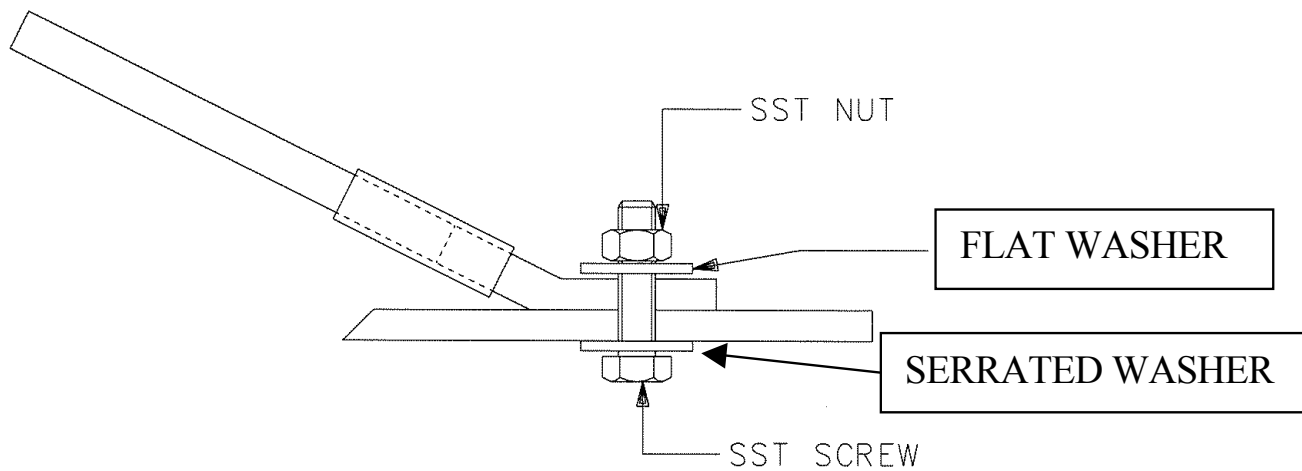


### **13.3 Symbol for a “Special purpose” ground. Rolls-Royce Energy uses it to signify “intrinsically safe” or (IS) ground.**



## **14 DETAILS OF GROUNDING/EARTHING ASSEMBLIES**

### **14.1 DETAIL A – TYPICAL GROUND/EARTH STRAP CONNECTION**

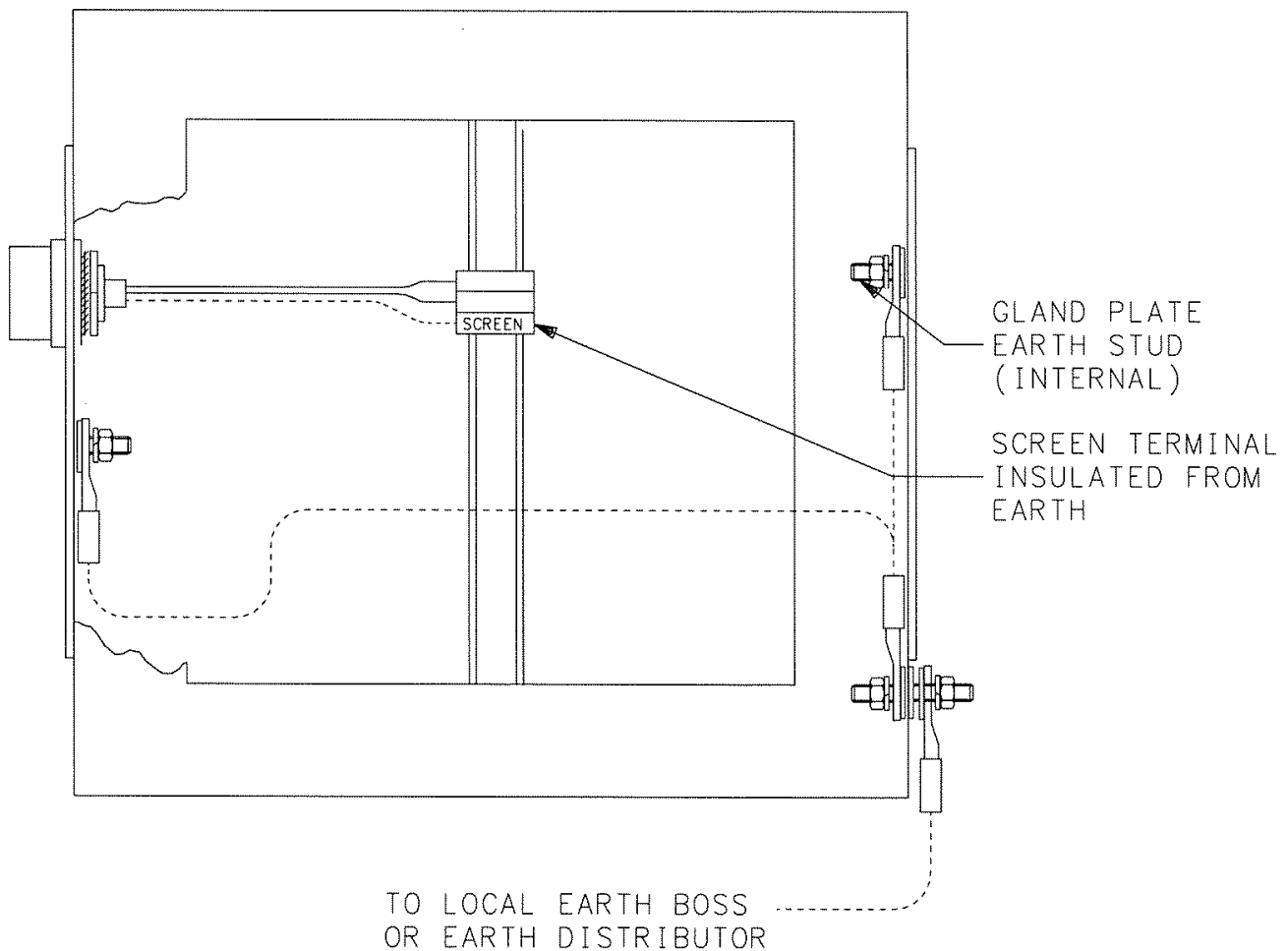


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## 14.2 TYPICAL JUNCTION BOX GROUNDING/EARTHING DETAIL

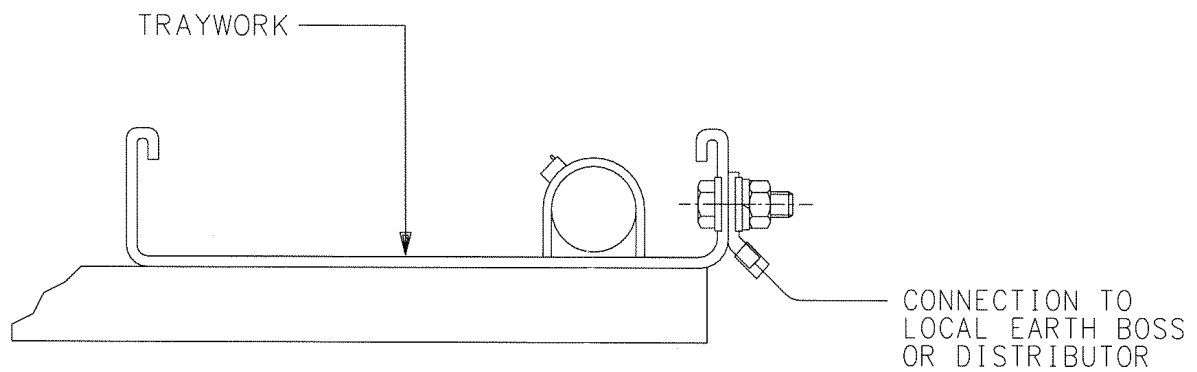


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### 14.3 TYPICAL CABLE TRAY GROUNDING/EARTHING

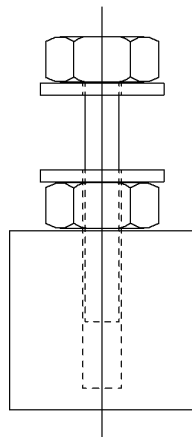


**Rolls-Royce**

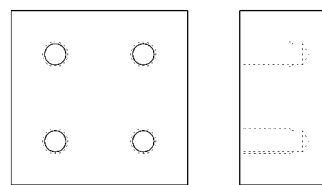
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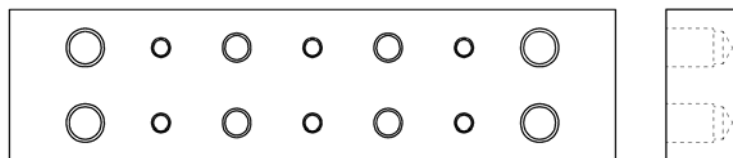
#### 14.4 TYPICAL SINGLE AND MULTIPLE POINT GROUND/EARTH CONNECTIONS



GROUND LUG- 'EARTH BOSS' SINGLE POINT



Customer Ground/Earthing Block



Multiple Point Grounding/Earthing Block for Skid Mounting

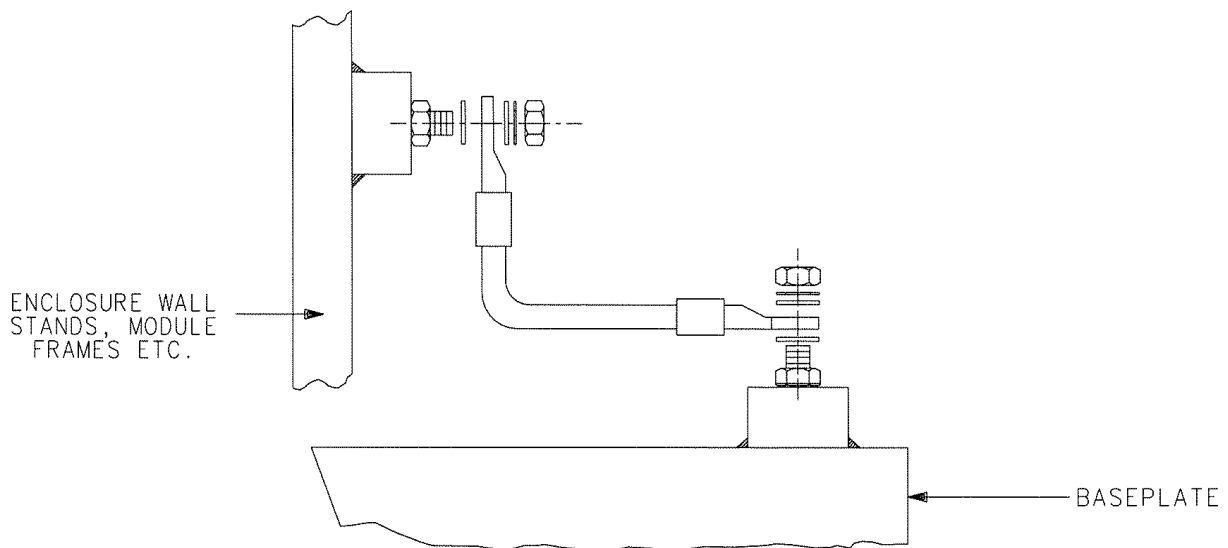


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## 14.5 TYPICAL GROUND/EARTH BOSS ASSEMBLY AND LOCAL BONDING



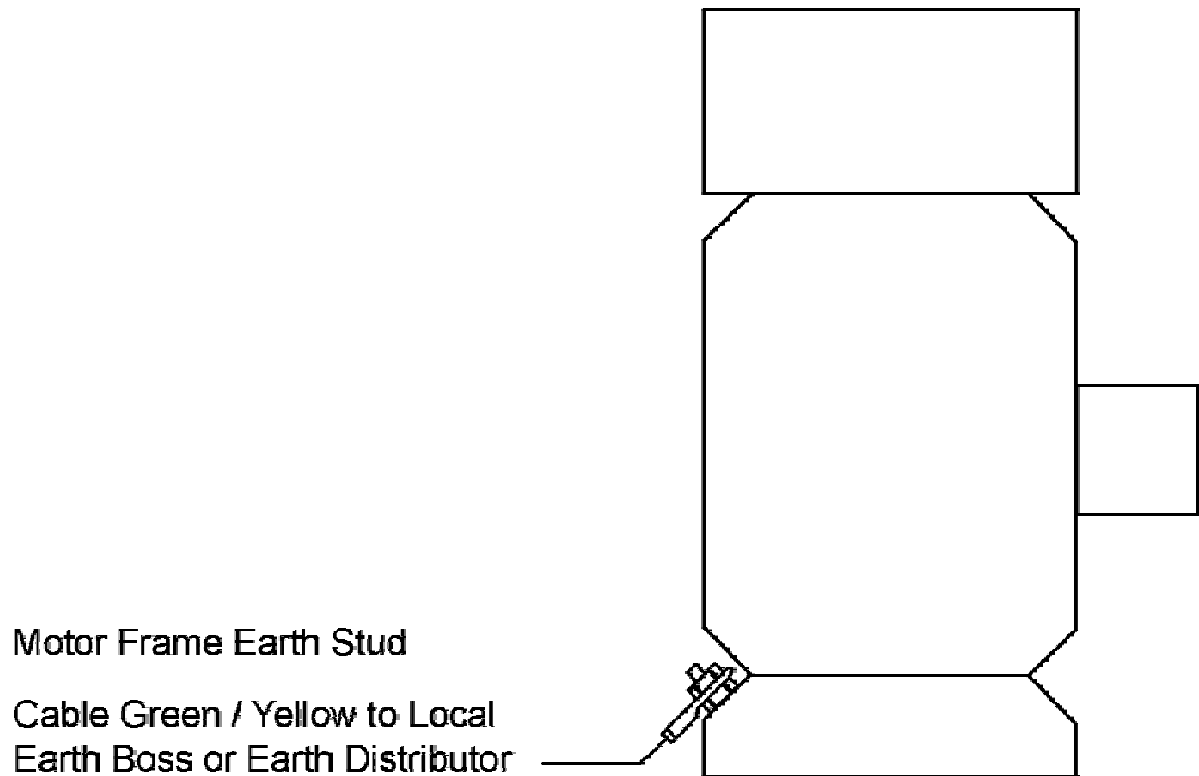
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**14.6 GROUNDING/EARTHING OF MOTORS AND HEATERS**



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# Rolls-Royce

## Global Engineering Reference

## GER 0144

Revision: 1

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### Water Quality Requirements for Cooling Water

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## **EXECUTIVE SUMMARY**

This document summarizes quality requirements for cooling water used in lube oil system heat exchangers. It does not address water injection applications for gas generators nor water quality for water mist extinguishing systems.

## **POINT OF EMBODIMENT**

Applies to all new equipment tenders, initiated after issue of this revision; it should not be applied retrospectively to production or legacy projects unless affected equipment overhaul or replacement is required.

Revision History			
Revision	Revision Description	Author	Approval Signature, Date
0	Initial issue to ECR 14552.	R. H. Marshall	P. Rainer 08 Feb 07
1	Added Export Controlled Statement as per ECR 37463	K. Fearn	



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TABLE OF CONTENTS

1 SCOPE..... 4

2 REFERENCE DOCUMENTS AND SPECIFICATIONS ..... 4

3 TYPES OF WATER SYSTEMS..... 4

4 GENERAL REQUIREMENTS ..... 5

5 WATER DELIVERY FILTRATION ..... 5

6 WATER TEMPERATURE LIMITS..... 5

7 WATER SUPPLY PRESSURE & FLOW RATE ..... 5



## **1 SCOPE**

1.1 For the purposes of this document only, the term "Rolls-Royce" shall be construed as meaning and / or referring to "Rolls-Royce Power Engineering plc." and "Rolls-Royce Energy Systems Inc." either jointly or individually.

**NOTE: This document is an Engineering Standard. No deviations are permitted to instructions or specifications herein other than those approved in writing by the PCB (Product Change Board).**

## **2 REFERENCE DOCUMENTS AND SPECIFICATIONS**

2.1 Water Treating, Section 11, Ecodyne MRM General Reference Paper, per G. Cash, VP, Ecodyne MRM, Rev 1974

2.2 GER 0023, Piping Specification

2.3 ANSI/API 662, 2nd Edition (Co-Registered with ISO), Plate Heat Exchangers for General Refinery Services, April 2002 (ISO 15547:2000)

2.4 ANSI/API 661, 6th Edition (Co-Registered with ISO), Air-Cooled Heat Exchangers for General Refinery Services, Feb. 2006 (ISO 13706-1)

2.5 Stainless Steel Advisory Service, SSAS Information Sheet No.4.92, Corrosion of Stainless Steels in Supply (Drinking) and Waste (Sewage) Water Systems

## **3 TYPES OF WATER SYSTEMS**

3.1 Closed loop system (normal for non-seawater) with duty cooler either by Rolls-Royce or customer, and reservoir with supply and return lines usually by customer.

**NOTE: Non-seawater means freshwater or freshwater-coolant mixture.**

3.2 Through/open loop system (normal for seawater) with supply and return lines and suction from / discharge to sea (or reservoir) usually by customer. A through system is possible with non-seawater.



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## **4 GENERAL REQUIREMENTS**

4.1 Chloride content of non-seawater used for cooling duty and hydrotest of austenitic SST pressure parts shall not exceed 50 ppm by weight (50 mg/kg).

4.1.1 Low levels of chloride (~ 1 ppm) limit bacterial fouling and stop any growth.

4.2 With seawater as cooling medium, refer to GER 0023 for standard piping materials .

4.3 pH value of water supply will vary depending upon water treatment process. Slightly alkaline (pH 9) is normal.

4.4 Total dissolved solids shall be minimized by suitable water treatment using ion exchange resins or similar.

4.5 Water/glycol mixes can be used to reduce freezing point, depending upon expected contract conditions.

## **5 WATER DELIVERY FILTRATION**

5.1 Filtration of supply water to the heat exchanger shall be better than 0.5 mm (500 micron) absolute (Beta ratio = 200).

## **6 WATER TEMPERATURE LIMITS**

6.1 Water supply temperature (minimum without antifreeze) is to be 5°C (41°F); otherwise it shall be 5°C above freeze point. Maximum supply temperature is 35 °C (95°F) which will require large flow rate; supply temperature should be as cool as possible within limits.

6.2 Re-circulatory water systems commonly have flow control devices (typically on cooler discharge) to maximize water discharge temperature. These can be orifices or valves. By maximizing the discharge temperature, flow quantity is minimized, which increases overall efficiency of the cooling system. Customer supplied cooler will remove heat from returned water.

6.3 Water discharge temperature in a through/open loop system using seawater should be limited to below 45°C (113°F) to suppress algae growth at discharge point.

## **7 WATER SUPPLY PRESSURE & FLOW RATE**

7.1 Water supply pressure is normally below 100 psi but is contract specific. Flow rate is contract specific, dependent upon thermal duty of the design.



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Rolls- Royce  
Gas Turbine Package  
Site Emissions &  
Enthalpy Testing

**Gas Turbine Package Site Emissions & Enthalpy Testing**



### 1.0 Introduction

This Test Procedure sets out the methods and procedures used for Site performance testing GT exhaust emissions and when required measuring exhaust enthalpy. This testing procedure will also be used when required to calculate exhaust enthalpy using the data acquired for volumetric flow rates. Emissions testing will take place in parallel with the main performance test and under the supervision of the RR Test Co-ordinator.

The following standards are applicable for the emissions testing:  
Code of Federal Regulations, Title 40, Part 60 (40CFR 60, Rev. July 1, 1995).

This procedure shall be used to confirm actual emission levels at various operating conditions with those established / guarantee emission levels and exhaust enthalpy for CCGT process plants where exhaust enthalpy is measured at the bypass stack.

### 2.0 Process Description

#### Required Test Instrumentation

- P3000 Portable Analyzer or equivalent
- Recommended Calibration Gas
- 50vppm Carbon Monoxide
- 20vppm Nitrogen Dioxide
- 15.0% Oxygen
- 1000vppm Carbon Monoxide
- 50vppm Nitric Oxide
- Balance Nitrogen
- Nitrogen, instrument grade
- Vane anemometer
- RTD probe

### General Information/Data

#### 40CFR 60, Method 10: Determination of Carbon Monoxide

This method is applicable for the determination of carbon monoxide emissions from stationary sources only when specified by the test procedures for determining compliance with new source performance standards. The test procedure will indicate whether a continuous or an integrated sample is to be used.

40CFR 60, Method 10 includes:

- Principle and Applicability
- Range and Sensitivity
- Interferences
- Precision and Accuracy
- Apparatus
- Reagents
- Procedure
- Calibration
- Calculation

Hydrocarbons



### General Information/Data

#### 40CFR 60, Method 25A: Determination of Total Gaseous Organic Concentration

This method applies to the measurement of total gaseous organic concentration of vapors consisting primarily of alkanes, alkenes, and / or arenes (aromatic hydrocarbons). The concentration is expressed in terms of propane (or other appropriate organic calibration gas) or in terms of carbon.

40CFR 60, Method 25A includes:

- Principle and Applicability
- Definitions
- Apparatus
- Calibration and Other Gases
- Measurement System Performance Specifications
- Pretest Preparations
- Emissions Measurement Test Procedure
- Organic Concentration Calculations

#### Exhaust Enthalpy

This is only required for Power generation projects where Rolls-Royce have provided an Exhaust Enthalpy guarantee. This makes use of the data collected for standard Site emissions test.

Method - Measure the exhaust gas flow and temperature across the exhaust stack using the two 3" diameter ports at 90° to each other used to measure emissions.

Readings will be taken at 6" intervals across the stack in the two directions and repeated at intervals of 20 minutes. The time of the readings will be recorded for each set of results.

The temperatures are averaged and, using the stack dimensions, the average Actual Volumetric Flow Rate calculated for each measurement set.

Using the corrections and Cp data values in the Performance Test Procedure and the Enthalpy Test Correction polynomials the Exhaust Energy is calculated and included in the overall Performance Test Report.

#### General Information (recorded once during testing):

- Customer Name
- Site Location
- Site Elevation
- Unit Serial Numbers (Gas Generator, Power Turbine, Compressor/Generator)
- On-Site Personnel Related to Testing: Customer, Contractor, Cooper...etc  
(Information should include location, phone and fax numbers)
- Gas Generator: Hours of Operation, Cleaning History, Attempted/Successful Starts
- Piping and Instrumentation Drawings
- Anti-Icing Status (if applicable, must be off)

#### General Data (recorded during each test (load) point)

- Test run number and data set
- Time of test run
- Ambient Temperature
- Valve Position (any valve that directly effects the operation of the unit(s):
  - Surge Valve
  - Bleed Valve





Purge Valve  
Unit Valves  
Station Valves  
Fuel Valves

### Final Report Format

The final performance test report shall be issued within thirty days from receipt of the laboratory gas analysis or completion of the field acceptance test. The following report format shall be used when not identified by contract.

#### Title Page:

- title of report
- date of test
- location of test
- equipment owner (customer/contractor)
- equipment serial numbers
- date of report

#### Table of Contents: (identifies the major subdivisions of the report)

##### Summary:

- shall concisely state and address test objective(s)
- test objective(s) shall be restated with results, conclusions, and references clearly identified

#### Body of Report:

- restates test objective(s)(guarantees)
- lists all agreements among the parties to the test
- description of equipment tested and all ancillary equipment that may influence test results
- line diagram identifying units being tested, field piping and valve configuration(s), and test instrumentation locations used during various parts of the test (ie... surge testing, performance testing, overspeed..etc..)
- a brief discussion of the test including:
  - (i) a brief description as to the manner in which testing was conducted
  - (ii) any deviations from the originally issued test procedure, with reasons
  - (iii) a brief history of the operations including startups and shutdowns of the unit(s) during testing with results, reasons, and conclusions

#### Appendices

Appendix 1 Identification, location, and operating conditions of test equipment used  
instrument calibration curves/certifications

Appendix 2 Reference Sheet:  
identifies all personnel present during testing

- (i) name
- (ii) title
- (ii) company name and address
- phone/fax number



## Authorisation and Change History

<b>Gas Turbine Package Site Emissions &amp; Enthalpy Testing</b>	
Lead Process User Authorisation: Dave Fry	Date: 15 Dec 2005
Quality Assurance Approval: Mary Christopher	Date: 15 Dec 2005

### Reason for issue:

Issue	Summary	Date
1	Initial Issue	15 Dec 2005

**Commissioning Spares - Two (2) Rolls-Royce Trent 60 WLE Gas Turbines-Generator Units**

Item No.	Description		Quantity	Unit
	Part Number	Part Name		
<b>MECHANICAL AREA:</b>				
	<b>99A05401 TRENT WLE</b>			
	<b>MISCELLANEOUS SPARES</b>			
1	RRE017644	COMMISSIONING KIT (MISC.HARDWARE)	1	SET
2	RRE032805	FIRE & GAS CALIBRATION KIT	1	SET
	<b>ZP0000386 GAS TURBINE</b>			
	<b>ZB0002114 GAS TURBINE</b>			
3	AS3209-020	O-RING - QUILL SHAFT	2	PIECE
4	AS43003-912	SEAL - O-RING	10	PIECE
5	AS43013-015	SEAL - O-RING, CHIP DET.	10	PIECE
6	AS43013-113	SEAL - O-RING	2	PIECE
7	AS43013-115	SEAL - O-RING, SPEED PROBE, (NH) GEARBOX	4	PIECE
8	AS43013-118	SEAL - O-RING	12	PIECE
9	AS43013-214	SEAL - O-RING, L1, 17 PUMP CONNECTIONS	4	PIECE
10	AS43013-216	SEAL - O-RING, OIL PUMP TO EGB	2	PIECE
11	AS43013-224	SEAL - O-RING, L21, L23 PUMP CONNECTIONS	4	PIECE
12	AS43013-252	SEAL - O-RING, EGB TO ENGINE	2	PIECE
13	AS43013-260	SEAL - O-RING	2	PIECE
14	AS43013-261	SEAL - O-RING, OIL PUMP TO EGB	4	PIECE
15	AS43013-269	SEAL - O-RING, EGB TO CLUTCH	2	PIECE
16	FK20158	SHIM, IGNITER - WLE	12	PIECE
17	FK20159	SHIM, IGNITER - WLE	12	PIECE
18	FK20160	SHIM, IGNITER - WLE	12	PIECE
19	LYB1424	GASKET - MOUNTING	8	PIECE
20	M83248-1-216	O-RING - PUMP FACE	2	PIECE
21	M83248-1-226	O-RING - CLUTCH/GEARBOX	2	PIECE
22	M83248-1-261	O-RING - QUILL SHAFT	2	PIECE
23	M83248-1-269	O-RING - CLUTCH/GEARBOX	2	PIECE
24	M83248-1-334	O-RING - QUILL SHAFT	10	PIECE
25	M83248-1-910	O-RING - SEAL, QDM	10	PIECE
26	S2357	GASKET - INJECTOR	96	PIECE
27	TRN11595	GASKET - OIL PUMP SCAVENGE MANIFOLD	2	PIECE
28	TRN11707	SEAL - 3" V-BAND FLANGE	8	PIECE
29	TRN11787	SEAL - P30 TRANSDUCER	6	PIECE
30	TRN16214	PLUG, IGNITER - WLE	4	PIECE
31	TRN17344	O-RING - INPUT COLLAR	2	PIECE
	<b>ZP0000394 LUBE OIL - GAS TURBINE</b>			
	<b>GED00016944 DIAGRAM - OIL SYSTEM (COMPONENT LIST GED00016954)</b>			
	<b>ZB0001995 CONSOLE - L/O (RRE029633)</b>			
32	RRE031288	ELEMENT - FILTER	2	PIECE
33	RRE031286	ELEMENT - FILTER	4	PIECE
34	RRE031290	ELEMENT - FILTER	2	PIECE

	<b>ZP0000408 WATER INJECTION SYSTEM</b>			
	<b>ZB0002099 SKID - WATER INJECTION</b>			
35	RREXXXXXX	ELEMENT - FILTER	2	PIECE
<b>ELECTRICAL AREA:</b>				
	<b>A. C. GENERATOR</b>			
36	RREXXXXXX	DIODE MODULE - (6) PER SET, (1) SET PER GENERATOR	2	SET
<b>INSTRUMENTATION &amp; CONTROLS AREA:</b>				
	<b>ZP0000404 GAS TURBINE DISTRIBUTED IO</b>			
	<b>ZB0002123 WIRING - DISTRIBUTED IO</b>			
37	RRE004098	TERMINAL WDU 2.5	48	PIECE
38	RRE004100	WSI 6 FUSED DISCONNECT 24VDC	40	PIECE
39	RRE004130	JUMBER BAR (10 POLE) for WSI 6	4	PIECE
40	RRE004121	#1-10 TERMINAL MARKER	8	PIECE
41	RRE004122	#11-20 TERMINAL MARKER	8	PIECE
42	RRE004101	TERMINAL END WAP 2.5	12	PIECE
	<b>ZB0002124 WIRING - DISTRIBUTED IO</b>			
43	RRE004741	DIODE	6	PIECE
44	RRE004132	JUMPER - 50 POLE	32	PIECE
45	RRE004098	TERMINAL WDU 2.5	148	PIECE
46	RRE004100	WSI 6 FUSED DISCONNECT 24VDC	40	PIECE
47	RRE004130	JUMBER BAR (10 POLE) for WSI 6	4	PIECE
48	RRE004121	#1-10 TERMINAL MARKER	8	PIECE
49	RRE004122	#11-20 TERMINAL MARKER	8	PIECE
	<b>ZB0002125 WIRING - DISTRIBUTED IO</b>			
50	RRE004098	TERMINAL WDU 2.5	48	PIECE
51	RRE004100	WSI 6 FUSED DISCONNECT 24VDC	40	PIECE
52	RRE004130	JUMBER BAR (10 POLE) for WSI 6	4	PIECE
53	RRE004121	#1-10 TERMINAL MARKER	10	PIECE
54	RRE004122	#11-20 TERMINAL MARKER	8	PIECE
55	RRE004101	TERMINAL END WAP 2.5	12	PIECE
	<b>ZP0000401 PANELS - GAS TURBINES CONTROL</b>			
	<b>ZB0002187 PANEL - UNIT CONTROL</b>			
56	RRE004741	DIODE	34	PIECE
57	RRE004098	TERMINAL WDU 2.5	256	PIECE
58	RRE004101	TERMINAL END WAP 2.5	94	PIECE
59	RRE004100	WSI 6 FUSED DISCONNECT 24VDC	256	PIECE
60	RRE004130	JUMPER BAR (10 POLE) For WSI 6	22	PIECE
61	RRE004132	50 POLE PLUGGABLE JUMPER	6	PIECE
62	RRE004131	10 POLE PLUGGABLE JUMPER	14	PIECE
63	RRE014493	2 POLE PLUGGABLE JUMPER	10	PIECE
64	RRE009303	BLUE END PLATE FOR WTR 2.5	6	PIECE
65	RRE026017	BLUE WTR 2.5 DISCONNECT TERMINAL	40	PIECE
66	RRE004121	#1-10 TERMINAL MARKER	20	PIECE
67	RRE004122	#11-20 TERMINAL MARKER	20	PIECE
68	RRE004123	#21-30 TERMINAL MARKER	20	PIECE
69	RRE004124	#31-40 TERMINAL MARKER	20	PIECE

70	210E111640	#41-50 TERMINAL MARKER	8	PIECE
71	299W073001	SIS/XLPE #14 GRAY WIRE	100	PIECE
72	299W073015	SIS/XLPE #16 GRAY WIRE	100	PIECE
73	299W073012	SIS/XLPE #18 GRAY WIRE	100	PIECE
74	299W073144	SIS/XLPE #12 RED WIRE	100	PIECE
75	299W073143	SIS/XLPE #14 RED WIRE	100	PIECE
76	299W073142	SIS/XLPE #16 RED WIRE	100	PIECE
77	299W073141	SIS/XLPE #18 RED WIRE	100	PIECE
78	299W073124	SIS/XLPE #12 BLACK WIRE	100	PIECE
79	299W073123	SIS/XLPE #14 BLACK WIRE	100	PIECE
80	299W073122	SIS/XLPE #16 BLACK WIRE	100	PIECE
81	299W073121	SIS/XLPE #18 BLACK WIRE	100	PIECE
82	299W073154	SIS/XLPE #12 GREEN WIRE	100	PIECE
83	299W063723	AEROSPACE CABLE 2C/#18 Red / Black	100	PIECE
84	299W063724	AEROSPACE CABLE 3C/#18 Red / Black / White	100	PIECE
	<b>TOTAL AMOUNT INCLUDED IN CONTRACT PRICE =</b>			

**Notes:** 1. Spare Part numbers are preliminary and subject to change during Engineering. Prices will remain firm.