



**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.....	12
	8.1 LIQUIDATED DAMAGES.....	12
	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 .....	13
	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



**Rolls-Royce**

**CONTRACT**  
EQUIPMENT SUPPLY

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.



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**CONTRACT**  
**EQUIPMENT SUPPLY**

**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. If the Change Order is not agreed to and signed within the 10 day period then the parties will, unless otherwise mutually agreed in writing, submit the dispute to binding arbitration before a single arbitrator for a decision to be rendered within 30 days administered by the American Arbitration Association under its Commercial Arbitration Rules. The fees for filing the dispute and the costs of the arbitrator shall be shared equally between the 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.

IN NO EVENT, WHETHER AS A RESULT OF BREACH OF CONTRACT, ALLEGED NEGLIGENCE, OR OTHERWISE, SHALL CUSTOMER BE LIABLE FOR INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES SUCH AS, BUT NOT LIMITED TO, LOSS OF PROFITS OR REVENUE.

## **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 completing 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:



**Rolls-Royce**

**CONTRACT**  
**EQUIPMENT SUPPLY**

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 (other than for a dispute with respect to Clause 3.5).

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, which consent shall not be unreasonably withheld. 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**

**CONTRACT**  
EQUIPMENT SUPPLY

Rolls-Royce Energy Systems Inc.

By \_\_\_\_\_

Title \_\_\_\_\_

Energy Parts Solutions, LLC

By *[Signature]*

Title VICE PRESIDENT



**Rolls-Royce**

**CONTRACT**  
**EQUIPMENT SUPPLY**

**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



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- 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



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- 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



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additional price adder.

- o One set of Coupling Installation Tooling
- o One GT Installation Kit
- o One Starter and Clutch Change out Kit
- o One Gas turbine transportation stand suitable for air freight
- o One set of Lifting beams for gas turbine transportation stand and gas turbine
- o One Baseplate Field Alignment Jig
- o One Gas turbine transportation stand suitable for air freight
- o 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:
  - o 98/37/EC The Supply of Machinery (Safety) Regulations
  - o 97/23/EC Pressure Equipment Directive (PED)
  - o 94/9/EC ATEX Directive (Electrical/Mechanical)
  - o 89/336/EEC The Electromagnetic Compatibility Regulations
  - o 73/23/EEC Low Voltage Equipment
  - o 93/465/EEC Rules for CE Marking
  - o ASME VIII Div 1 U-Stamped Pressure Vessel
  - o ASME B31.3 and BS EN 13480 Process Piping
  - o ASME B16.5 Pipe Flanges and Fittings
  - o ASME V Non-Destructive Testing
  - o ASME 1X/BS EN 25817/PED Welding Piping/Weld Acceptance
  - o AWS D1.1/BS 5950 Structural Design Fabrication
  - o Material Traceability Certification to Section 3.1 of EN-10204
  - o Hazardous Area Classification North America Class 1 Div 2
  - o Institute of Petroleum Model Code of Safe Practice Part 15
  - o Fire Codes – NFPA 72 / NFPA 12
  - o Motors, Heaters, and Lights are designed per NEC
  - o Package electrical wirings are designed per electrical codes suitable for installation in North America



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**APPENDIX B - TECHNICAL Specifications**

## 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**

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**APPENDIX B - TECHNICAL Specifications**

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.



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**APPENDIX B - TECHNICAL Specifications**

***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:

Pressure (kPag) & Temperature (°C)	Usage
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**

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.		
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 SOx 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.



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**APPENDIX B - TECHNICAL Specifications**

- 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.



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**CONTRACT**

**APPENDIX B - TECHNICAL Specifications**

***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.



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**APPENDIX B - TECHNICAL Specifications**

**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.



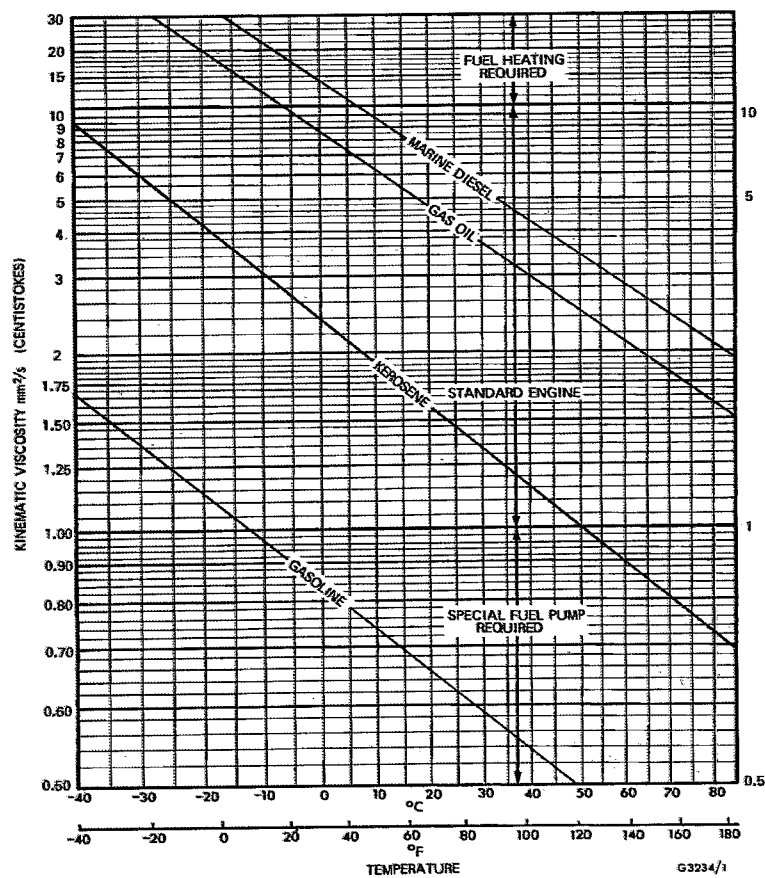
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APPENDIX B - TECHNICAL Specifications

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  $200 \text{ kJ/s}$  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







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APPENDIX B - TECHNICAL Specifications

**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". Consult Rolls-Royce for expected unit life.		
	% 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:
- $\text{Acceptable limit} = 0.5\text{wppm} \times \text{LCV (kJ/kg)} / 43\,000\text{kJ/kg}$
- 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.



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APPENDIX B - TECHNICAL Specifications

**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.				



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**APPENDIX B - TECHNICAL Specifications**

- 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 $\mu$ 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>,  $\mu$ S = microSiemen,  $\mu$ 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.**

Air contaminants	Units See Note A	Rolls-Royce air contaminant limits See Note B
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**

Air constituents/contaminants	Units See Note A	Rolls-Royce acceptable range for clean dry air See Notes B, C and D
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) =  $1 \times 10^{-6}$



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**APPENDIX B - TECHNICAL Specifications**

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 O-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%	Demin.Water 70%	MA 10%	CF 20%	Demin.Water 70%	EG 10%
-15°C < T < -5°C (5°F < T < 23°F)	CF 20%	Demin.Water 60%	MA 20%	CF 20%	Demin.Water 55%	EG 25%
	CF 20%	Demin.Water 45%	IPA 35%	CF 20%	Demin.Water 45%	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%	WATER 75%	MA 11%	R-MC CS 14%	WATER 74%	EG 12%
-15°C < T < -5°C (5°F < T < 23°F)	R-MC CS 14%	WATER 63%	MA 23%	R-MC CS 14%	WATER 60%	EG 26%
	R-MC CS 14%	WATER 48%	IPA 38%	R-MC CS 14%	WATER 48%	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%	MA 10%	WATER 85%	EG 15%	WATER 75%	IPA 25%
-15°C < T < -5°C (5°F < T < 23°F)	WATER 75%	MA 25%	WATER 70%	EG 30%	WATER 55%	IPA 45%
	MA Methyl Alcohol	EG Ethylene Glycol	IPA Isopropyl Alcohol			



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APPENDIX B - TECHNICAL Specifications

**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.



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APPENDIX B - TECHNICAL Specifications

**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	-



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**APPENDIX B - TECHNICAL Specifications**

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.



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APPENDIX B - TECHNICAL Specifications

***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.

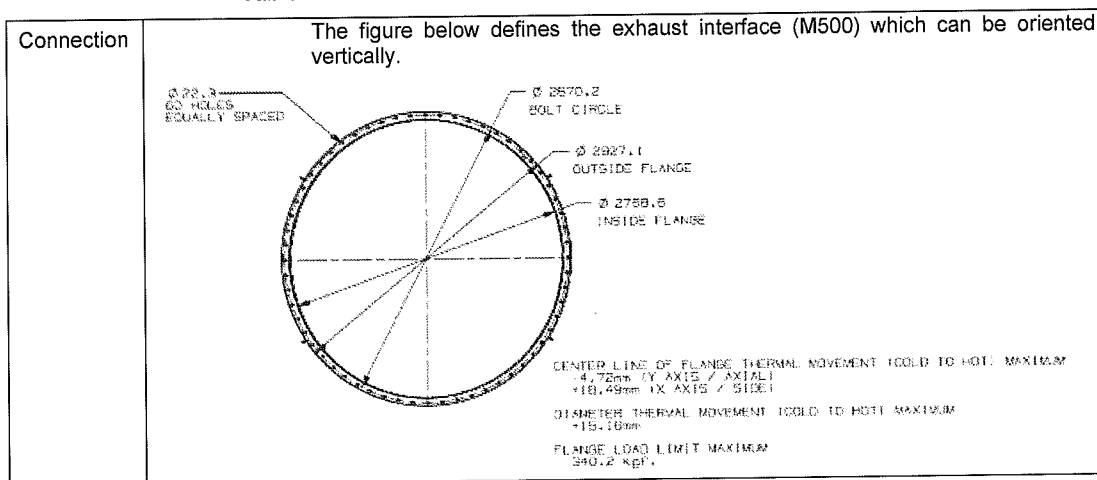


**TRENT 60 GENSET – INTERFACE REQUIREMENTS**

**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)**



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



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APPENDIX B - TECHNICAL Specifications

***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





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APPENDIX B - TECHNICAL Specifications

***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.



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APPENDIX B - TECHNICAL Specifications

***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



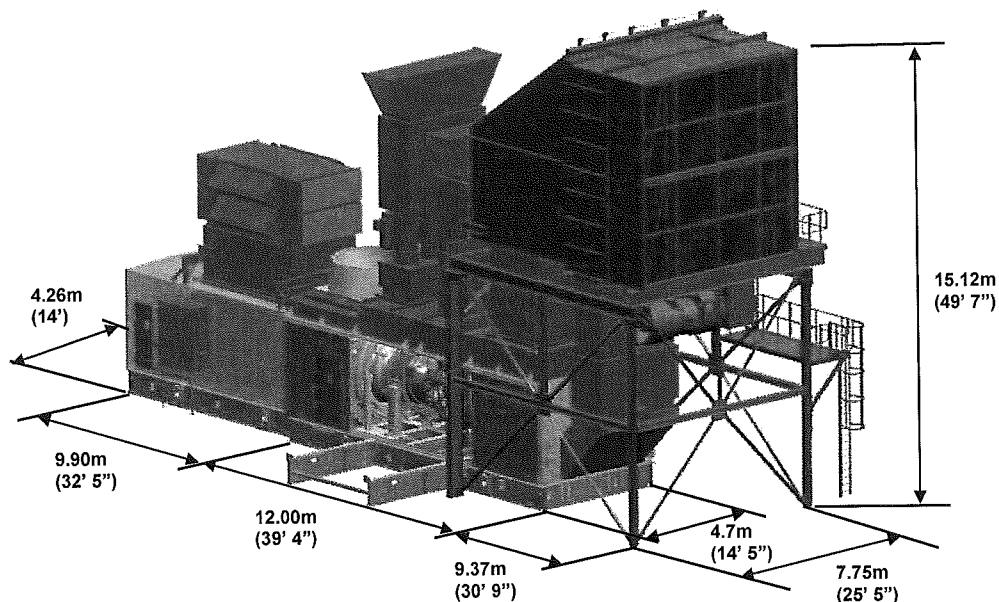
## **TRENT 60 WLE - PACKAGE**

### **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 plinth, 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.

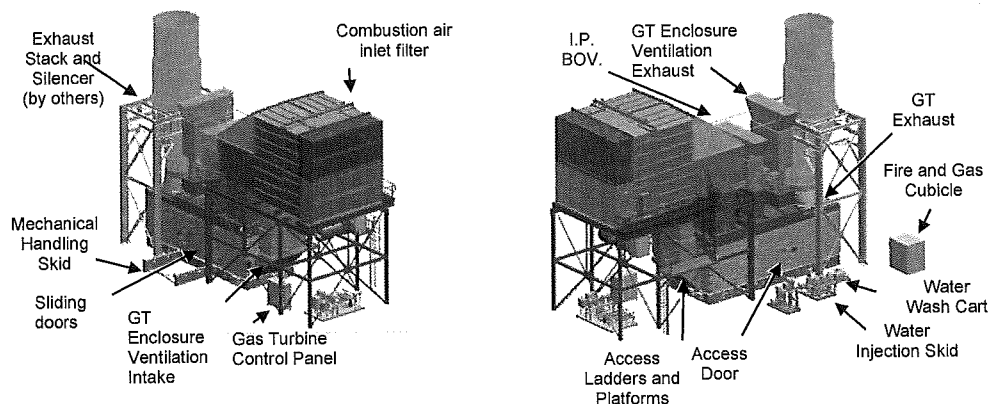


- c. Control System – Located though the package as distributed IO with the package and control system requiring a control panel in the control room with limited interconnection to the Gas Turbine Module. These control cabinet include the Engine Control System (ECS), Package Control System (PCS), fire 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.

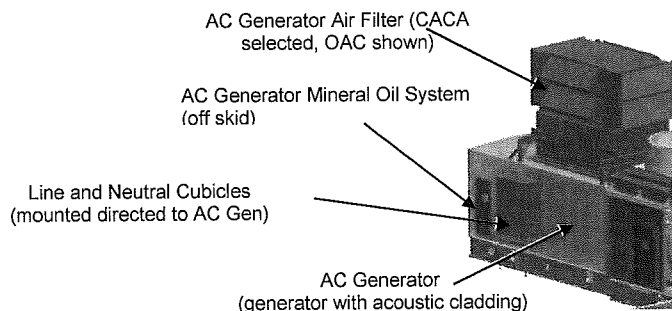
Each of these modules provides a distinct series of functions that in combination enable the package to operate.

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**



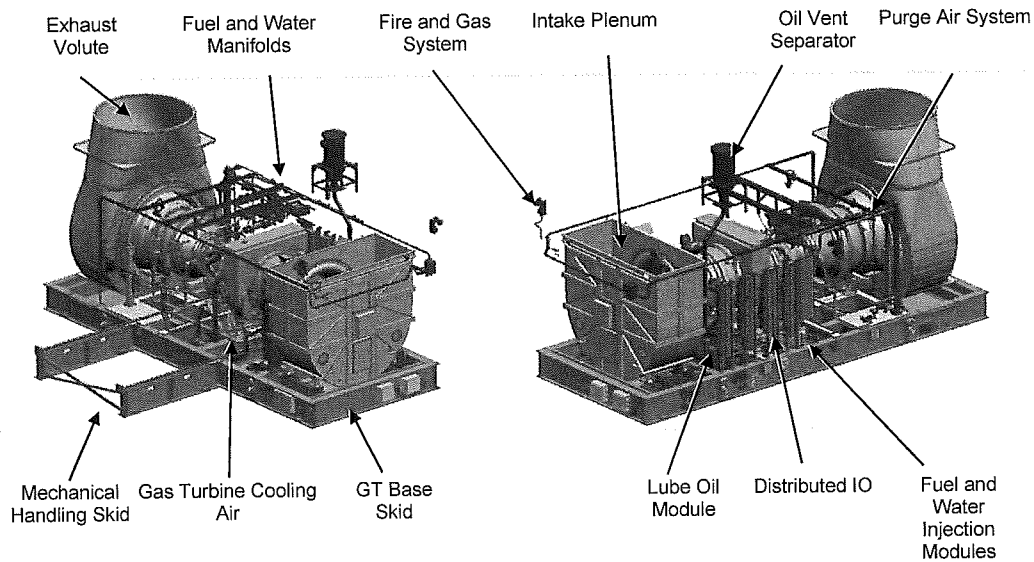


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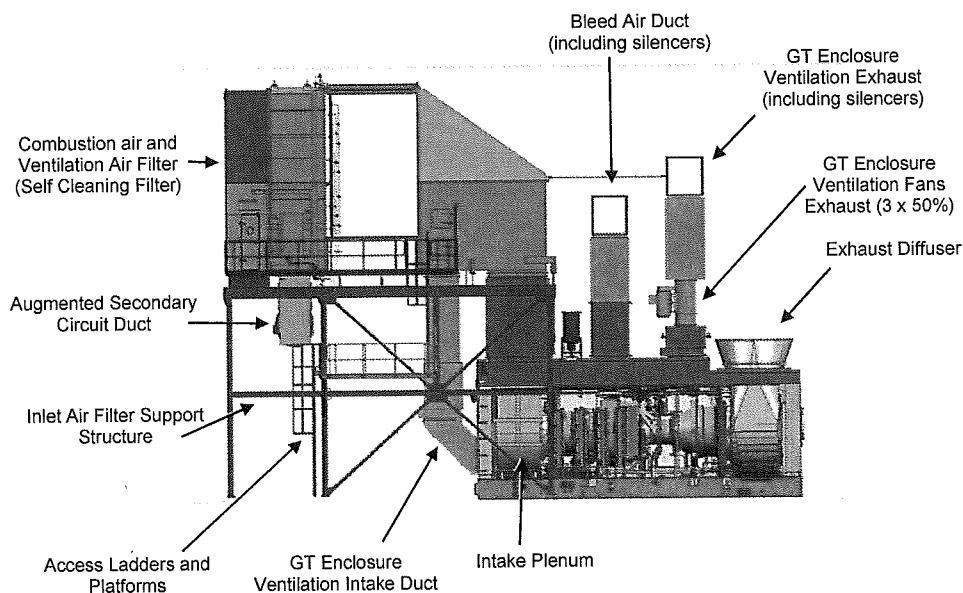
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APPENDIX B - TECHNICAL Specifications

**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 Panel (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.