

**TRENT 60 WLE - PACKAGE****DESIGN CONDITIONS**

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

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



**Rolls-Royce**

**CONTRACT**

APPENDIX C - PAYMENT Schedule, DELIVERY AND Documentation Schedule

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

• **Base Scope of Supply and Price**

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

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

• **Currency**

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

• **Payment Schedule**

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

• **Commercial Notes**

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



# Rolls-Royce

## CONTRACT

### APPENDIX C - PAYMENT Schedule, DELIVERY AND Documentation Schedule

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

- **Guaranteed Delivery Schedule:**

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

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

- **Documentation Delivery Schedule:**

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

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

- **Liquidated Damages:**

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

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

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





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• **Guaranteed Performance Levels:**

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



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• Natural Gas Performance Guarantees:

[TO BE DETERMINED UPON REVIEW OF SITE CONDITIONS]

The following performance parameters supersede all previously issued guarantees, and are guaranteed at a the Reference Conditions for Guarantee Performance described in this document, unless otherwise stated in the conditions column.					
Parameter	Unit	Value	Conditions	Fig	Definition
Gross Power	kWe	XX	New and Clean, Base load operation	-	1 - Gross Power
Gross Heat Rate (LHV)	kJ/kWe.hr	XX	New and Clean, Base load operation	-	2 - Gross Heat Rate
REFERENCE CONDITIONS					
Site Conditions			Natural Gas Fuel		
Ambient temperature (Dry Bulb)	°C	XX	Methane (CH4)	% mol	XX
Relative Humidity	%	XX	Ethane (C2H6)	% mol	XX
Ambient pressure	kPa	XX	Propane (C3H8)	% mol	XX
Altitude - For information only	m asl	XX	i-Butane (C4H10i)	% mol	XX
Electrical System			n-Butane (C4H10n)	% mol	XX
Power Factor at generator terminals	-	XX	i-Pentane (C5H12i)	% mol	XX
Generating frequency	Hz	XX	n-Pentane (C5H12n)	% mol	XX
Generating voltage at generator terminals	kV	XX	Hexane (C6H14)	% mol	XX
Gas Turbine			Nitrogen (N2)	% mol	XX
Gas Turbine	-	Trent 60	Carbon Dioxide (CO2)	% mol	XX
Combustion System	-	WLE			
Configuration	-	Dual Fuel	Fuel LHV		
Operation	-	Base continuous	Fuel Supply / Water Supply		
Condition	-	New and Clean	Fuel Gas Pressure (Guarantee Point)	bar (a)	XX
Operating Hours	hr	< 100 fired	Fuel Gas Temperature (Guarantee Point)	°C	XX
Design Temperature	°C	15 (Gas Fuel)	Water Pressure (Water Injection)	bar (a)	XX
Inlet Installation Losses (Guarantee Point)	mm H2O	XX	Water Temperature (Water Injection)	°C	XX
Exhaust Installation Losses (Guarantee Point)	mm H2O	XX	Water Pressure (Evap Cooler)	bar (a)	XX
Inlet Cooling	-	None	Water Temperature (Evap Cooler)	°C	XX
Inlet Cooling Operational	-	N/A	Performance Guarantees Definitions		
Performance Deck	-	eTrent v7.1.2	Definitions	Performance Definitions - Appendix D	
Performance Test			Units	SI Units	
Protocol	STP No. G.7.W		Natural Gas Quality	Interface Definition - Appendix B	
Correction Curves	eTrent Method		Ambient Air	Interface Definition - Appendix B	
Instrument Tolerance:	ASME PTC19.1		Water Quality	Interface Definition - Appendix B	



Rolls-Royce

• Liquid Fuel Performance Guarantees:

[To BE DETERMINED UPON REVIEW OF SITE CONDITIONS]

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

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

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

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

## APPENDIX F – SPECIMEN INSURANCE POLICY

1-26-01 4:37PMROLLS ROYCE

7-740 393 8179

7-740 393 8179

7-740 393 8179

**PRODUCER**  
**PAMELA THOMAS (312) 627-6262**  
**MARSH USA INC.**  
**609 WEST MADRID STREET**  
**CHICAGO, IL 60601**

**CERTIFICATE NUMBER**  
**CHS-000677486-00**

**THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER OTHER THAN THOSE PROVIDED IN THE POLICY. THIS CERTIFICATE DOES NOT AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICY AS DESCRIBED HEREIN.**

COMPANIES AFFORDING COVERAGE	
COMPANY	A ROYAL & SUN ALLIANCE
COMPANY	B FEDERAL INSURANCE CO
COMPANY	C
COMPANY	D

**INSURED**  
**Rolls-Royce Energy Systems**  
**Attn: Joe Long**  
**14650 Cantwell on Canter Dr**  
**Chantilly, VA 20151**

**THIS IS TO CERTIFY THAT POLICIES OF INSURANCE DESCRIBED HEREIN HAVE BEEN ISSUED TO THE INSURED NAMED HEREIN FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO THE POLICY, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, CONDITIONS AND EXCLUSIONS OF SUCH POLICY DOCUMENTS.**

CO. LTR.	TYPE OF INSURANCE	POLICY NUMBER	POLICY EFFECTIVE DATE (MM/DD/YYYY)	POLICY EXPIRATION DATE (MM/DD/YYYY)	LIMITS
A	GENERAL LIABILITY	RIX 7007-11-000Y	05/01/01	05/01/02	GENERAL AGGREGATE \$ 5,000,000 PRODUCTS - COMPOUND \$ 5,000,000 PERSONAL & ADJUTORY \$ 5,000,000 EACH OCCURRENCE \$ 5,000,000 FIRE DAMAGE (Any one line) \$ 50,000 MED EXP (Any one person) \$ 5,000
	<input checked="" type="checkbox"/> COMMERCIAL GENERAL LIABILITY <input checked="" type="checkbox"/> GLASS/PAINT <input type="checkbox"/> OCCUP <input type="checkbox"/> CHAIRS & CONTRACTORS' WORK				
	B AUTO/BOAT LIABILITY <input checked="" type="checkbox"/> ANY AUTO ALL OWNED AUTOS NON-OWNED AUTOS \$250 DEDUCTIBLE FOR COMP & COLLISION	7324-57-07 (ADS) 7324-57-11 (TX) 73-24-57-10 (VA)	05/01/01 05/01/01 05/01/01	05/01/02 05/01/02 05/01/02	COMBINED SINGLE LIMIT \$ 2,000,000  BOAT LIABILITY \$ BOAT LIABILITY \$ PROPERTY DAMAGE \$ AUTO ONLY - EA ACCIDENT \$ OTHER THAN AUTO ONLY \$ EACH ACCIDENT \$ AGGREGATE \$ EACH OCCURRENCE \$ NONPATE \$
	C BURGLARY LIABILITY ANY AUTO				
B	EXCESS LIABILITY				
	UMBRELLA FORM OTHER THAN UMBRELLA FORM				
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY THE PROPRIETOR/ PARTNER/ SCHEDULED/ OTHERS ARE <input checked="" type="checkbox"/> IND. <input type="checkbox"/> SEC.	WIC 7164-63-28	05/01/01	05/01/02	\$ 2,000,000 \$ 2,000,000 \$ 2,000,000
	OTHER				

**RECORD ITEM OF OPERATIONS/LOCAL/RESPONSE/STATE/OTHER ITEMS (LIMITS MAY BE SUBJECT TO DEDUCTIBLES OR RETENTION)**

**FOR EVIDENCE ONLY**

**SHOULD ANY OF THE POLICIES DESCRIBED HEREIN BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, THE INSURED HEREOFOR COVERAGE WILL BE FORFEIT TO THE EXTENT OF THE CANCELLATION DATE. THE CERTIFICATE AND/OR POLICY SHALL BE VOID TO THE EXTENT OF THE CANCELLATION DATE. THE CERTIFICATE AND/OR POLICY SHALL BE VOID TO THE EXTENT OF THE CANCELLATION DATE.**

**MARSH USA INC.**  
 Attn: Lisa M. Lynch

*E. J. Lynch*

**APPENDIX G – CANCELLATION SCHEDULE**

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

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

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



**Rolls-Royce**

**CONTRACT**

Appendix H – Site Performance Test Protocol

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

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



**Rolls-Royce**

**CONTRACT**

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**ATTACHMENTS**

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



# Rolls-Royce Standard Document Requirements List (SDRL) TRENT 60 (Phase IV) WLE Dual Fuel On-Shore Power Generation

Customer P1797

Project Number

P.O. Date TBD

Ship Date TBD

Project Trent Phase IV Power Generation Packa

Ex-Works Aug-10

Revision A

Revision Date April, 2010

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

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

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

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

NOTES:

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



**Rolls-Royce**

## **Rolls-Royce Energy Systems Inc.**

### **Trent WLE Power Generation Inspection and Test Plan**

**Project: 2 X Trent 60 WLE, DF**

**Issue: Certified**

**Issue Date: 28 April 2010**

**EXPORT-CONTROLLED DOCUMENT**

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

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## Responsible Party

1 = Rolls-Royce Energy Systems Inc.  
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# Revision Index

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

## Definitions

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

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

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

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

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

Notes:

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

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

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# General

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

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# Baseplate

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

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# Fuel Module

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

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

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# Fuel In-skid Interconnect System

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

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# GT Lube Oil Console

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

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

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# GT Lube Oil System

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

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# Unit Control Panel (UCP)

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

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# Air Intake Filter System

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

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

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

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# Trent Gas Turbine

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

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

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

Note: 1.) An assembled system operational test is performed in the field during commissioning.  
 2.) CO<sub>2</sub> bottles are not included.

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# Coupling

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

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# Air Cooled Generator

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

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REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS				
				1	2	3	4					
<b>Welded Frame</b>												
14	Review and approve weld procedures and welder qualifications (PQR, WPS and WPQ)	Supplier Procedure	Specification	A	D							
15	Review and approve NDT procedure and operator qualification	Supplier Procedure	Specification	A	D							
16	Certification for materials for frame housing, lifting lugs and filler metals	Specification	Acceptance Report	R	D							
17	<ul style="list-style-type: none"> <li>Weld inspection: visual and dimensional</li> <li>100% NDT of lifting lugs</li> </ul>	Supplier Procedure	Drawing	R	D							
18	Preparation for painting: shot blasting, cleanliness before painting	Supplier Procedure	Reports	R	D							
19	Paint inspection: paint thickness and adhesion	Supplier Procedure	Reports	R	D							
20	Final inspection: dimensional, visual and marking	Drawing	Drawing	R	D							
21	Certificate of conformity	Purchase Order	Specification	R	D							
<b>Copper Stator</b>												
22	<ul style="list-style-type: none"> <li>Identification operations</li> <li>Electrical test</li> </ul>	Supplier Procedure	Specification	R	D							
23	Dimensional inspection	Supplier Procedure	Specification	R	D							
24	Certificate of conformity	Purchase Order	Specification	R	D							
<b>Bearings</b>												
25	Material traceability: shells - white metal chemical composition	EN 10204 3.1	Specification	R	D							
26	<ul style="list-style-type: none"> <li>Ultrasonic test</li> <li>Dimensional inspection</li> <li>Geometric inspection</li> <li>Visual inspection</li> </ul>	ISO 4386 & EN 10204 3.1	Specification	R	D							
27	Identification of parts	Supplier Procedure	Specification	R	D							
28	Certificate of conformity	Purchase Order	Specification	R	D							
<table border="1" style="width: 100%;"> <tr> <td style="width: 40%;"> <b>Responsible Party</b>  1 = Rolls-Royce Energy Systems Inc.  2 = Supplier  3 = Customer or Customer Agency  4 = Third Party </td> <td style="width: 60%;"> A = Approval Required  D = Document Required  O = Observation Point (Requires 14 calendar days advanced notification)  R = Review Required  W = Witness Point (Requires 14 calendar days advanced notification) </td> </tr> <tr> <td>Project: 2XTrent 60 WLE</td> <td> Doc.: GEDXXXXXX      Rev.: 000 </td> </tr> </table>									<b>Responsible Party</b> 1 = Rolls-Royce Energy Systems Inc. 2 = Supplier 3 = Customer or Customer Agency 4 = Third Party	A = Approval Required D = Document Required O = Observation Point (Requires 14 calendar days advanced notification) R = Review Required W = Witness Point (Requires 14 calendar days advanced notification)	Project: 2XTrent 60 WLE	Doc.: GEDXXXXXX      Rev.: 000
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REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	RESPONSIBLE PARTY				REMARKS
				1	2	3	4	
<b>Balanced Rotor</b>								
29	Rotor: iron sheet and winding inspections	Supplier Procedure	Drawing	R	D			
30	Machined rotor: dimensional and geometric inspection	Supplier Procedure	Drawing	R	D			
31	Balancing inspection (pre-balancing)	Supplier Procedure	Drawing	R	D			
32	Electrical and dielectrical inspections	Supplier Procedure	Drawing	R	D			
<b>Assembled Stator</b>								
33	Stacked lantern <ul style="list-style-type: none"> <li>Sheet dimensional inspection</li> <li>Magnetization test</li> </ul>	Supplier Procedure	Drawing	R	D			
34	Wound lantern: electrical and dielectrical inspections during winding, before and after VPI	Supplier Procedure	Drawing	R	D			
35	Machined frame <ul style="list-style-type: none"> <li>Dimensional inspection</li> <li>Geometrical inspection</li> </ul>	Supplier Procedure	Drawing	R	D			
36	Assembled stator: electrical and dielectrical inspections	Supplier Procedure	Drawing	R	D			
<b>General Assembly and Tests</b>								
37	Generator general assembly <ul style="list-style-type: none"> <li>Air gap</li> <li>Clearance of rotor readings</li> </ul>	Drawing	Drawing	R	D			
38	Generator pass-off test	Supplier Procedure	Supplier Procedure	O	D			All units on contract
39	Test machine on bench <ul style="list-style-type: none"> <li>Generator performance type test on first machine of a new design</li> <li>Excitation regulation static tests on single cubicle (GCP)</li> <li>Bearings inspection and insulation measurement</li> </ul>	Approved Procedure	Test Reports	W	D			First of design only
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 40%;"> <p><u>Responsible Party</u></p> <p>1 = Rolls-Royce Energy Systems Inc.</p> <p>2 = Supplier</p> <p>3 = Customer or Customer Agency</p> <p>4 = Third Party</p> </div> <div style="width: 40%;"> <p>A = Approval Required</p> <p>D = Document Required</p> <p>O = Observation Point (Requires 14 calendar days advanced notification)</p> <p>R = Review Required</p> <p>W = Witness Point (Requires 14 calendar days advanced notification)</p> </div> <div style="width: 15%; text-align: right;"> <p>Doc.: GEDXXXXXX</p> <p>Rev.: 000</p> </div> </div> <p>Project: 2XTrent 60 WLE</p>								

				RESPONSIBLE PARTY				
REF. NO.	ACTIVITY	PROCEDURE	ACCEPTANCE CRITERIA	1	2	3	4	REMARKS
40	Final inspection <ul style="list-style-type: none"> <li>Nameplate checking</li> <li>Final dimensional interface</li> <li>Outline dimensional readings</li> <li>Preparation, cleanliness before painting</li> <li>Paint thickness and adhesion</li> </ul>	GQP F.2.5	Drawing, Specification & Purchase Order	O	D	O		
41	Shipping <ul style="list-style-type: none"> <li>Identification inspection</li> <li>Protection inspection</li> <li>Packaging inspection for shipping</li> <li>Weight recording</li> </ul>	GQP F.2.5	Drawing, Specification & Purchase Order	R	D			
42	Documentation review	GQP F.2.5	Purchase Order	O	D			
43	Shipping release (RRESI approval required for supplier to ship)	LOP F.2.3-1	LOP F.2.3-1	W, A	D			

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# Generator Control Panel

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

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# Mineral Lube Oil Console

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

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# Water Injection System

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

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# Liquid Fuel Forwarding Skid

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

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# Trent Testing, Packaging, and Shipping

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

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## Abbreviations

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


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<div>  <b>Rolls-Royce</b> </div>		<div> <div>GENERAL ARRANGEMENT</div> <div>TRENT 60 WLE</div> </div>	
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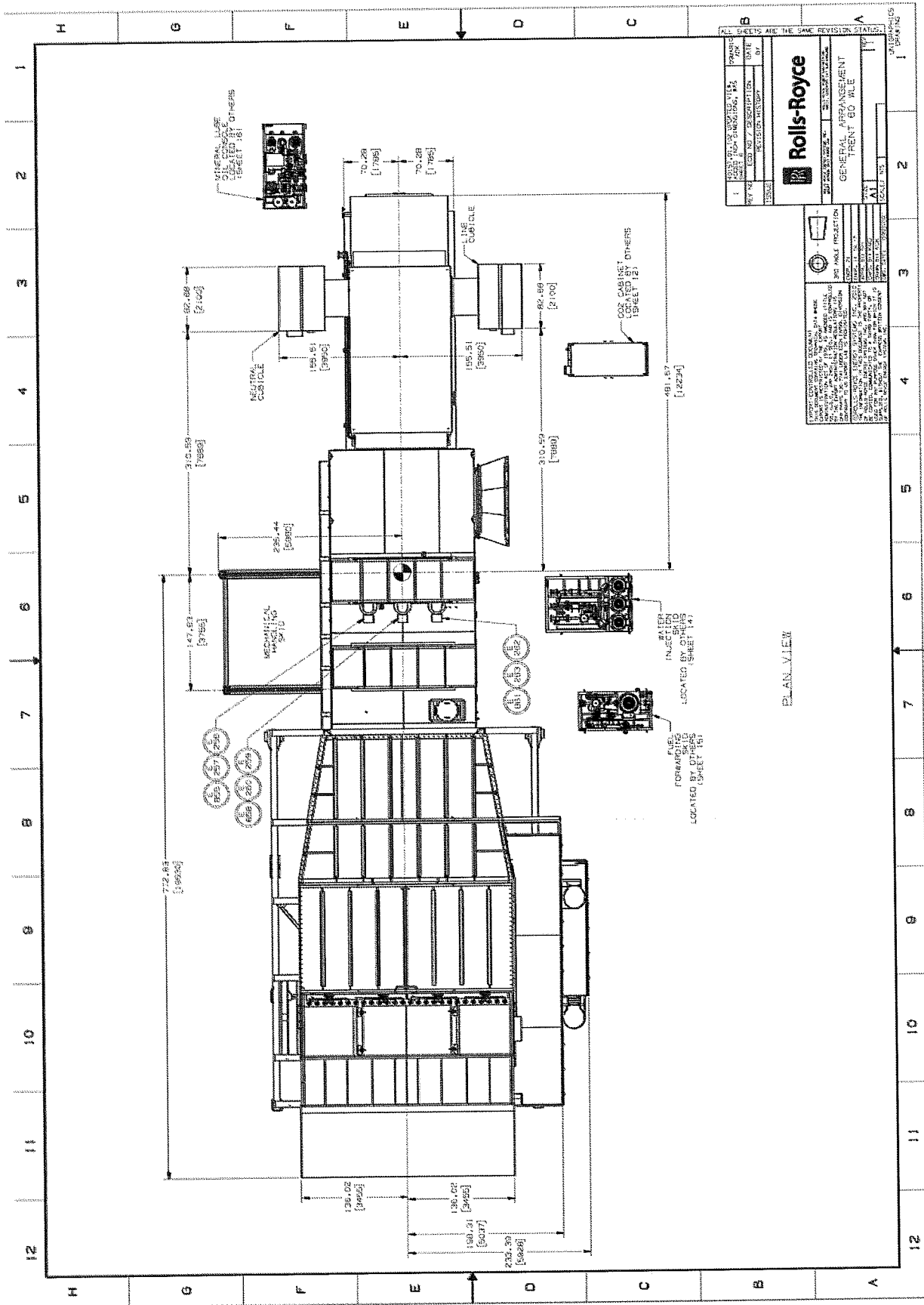
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PLAN VIEW

ALL SHEETS ARE THE SAME REVISION STATUS.

1		2		3		4		5		6		7		8		9		10		11		12	
Rolls-Royce																							
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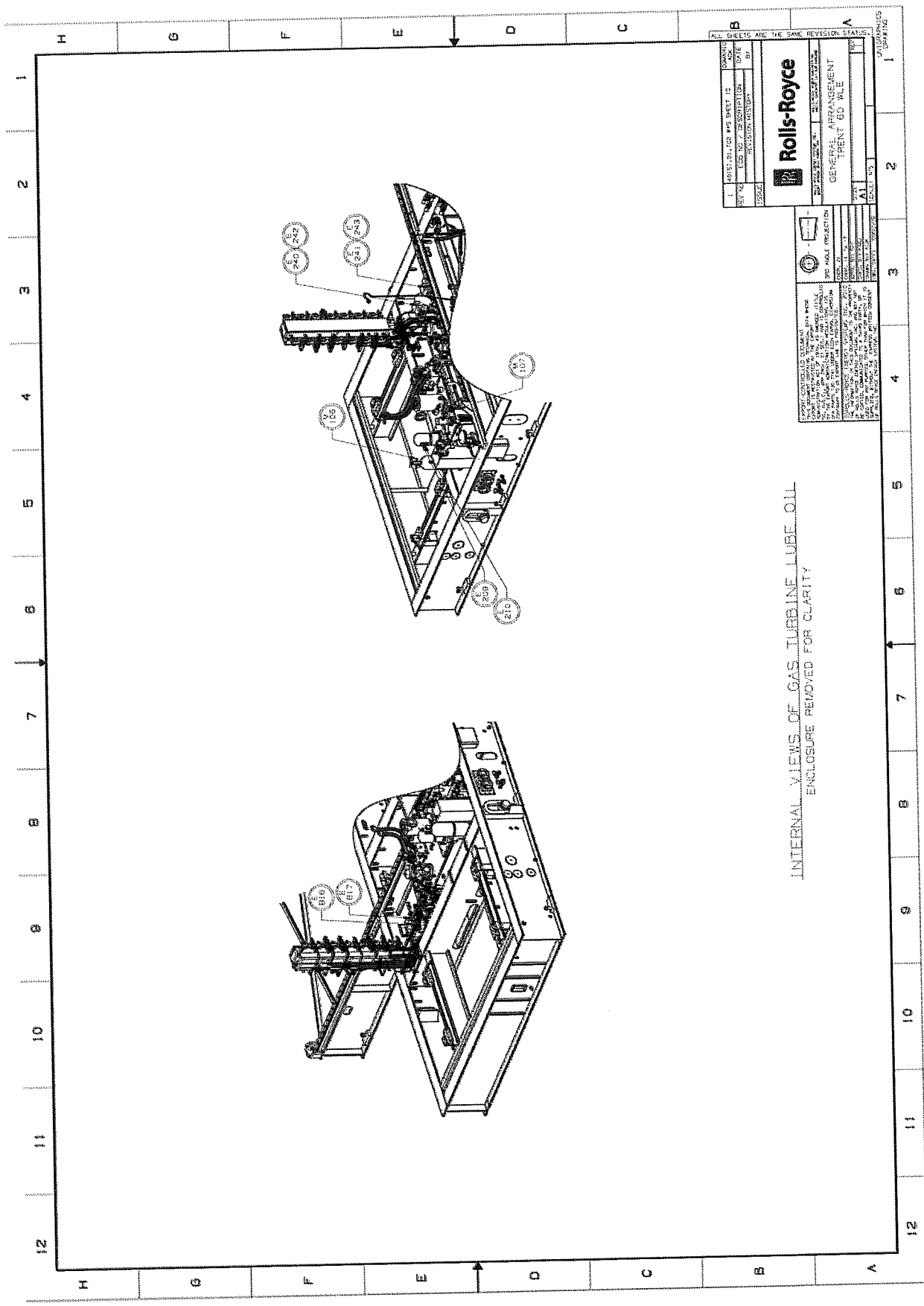
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ENCLOSURE REMOVED FOR CLARITY

Rolls-Royce

GENERAL ARRANGEMENT  
TRENK GO FILE

DATE: 1952  
BY: 1352

1. 14015, 141, 142 AND 143 SHEET 12

2. 14015, 141, 142 AND 143 SHEET 12

3. 14015, 141, 142 AND 143 SHEET 12

4. 14015, 141, 142 AND 143 SHEET 12

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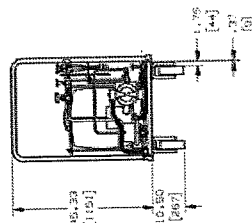
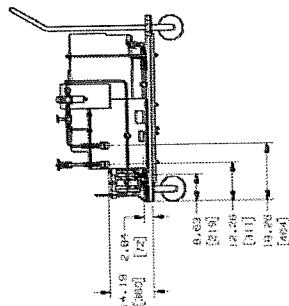
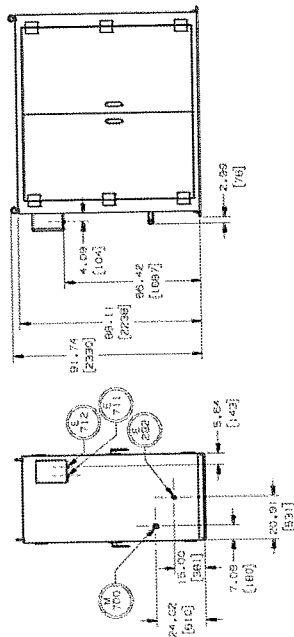
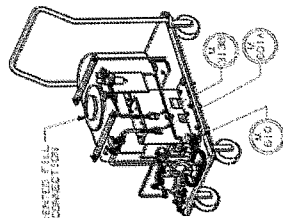
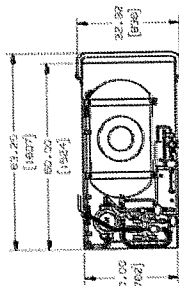
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12. 14015, 141, 142 AND 143 SHEET 12

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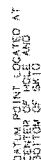


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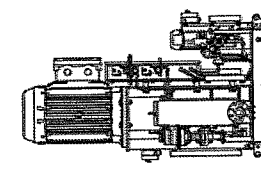
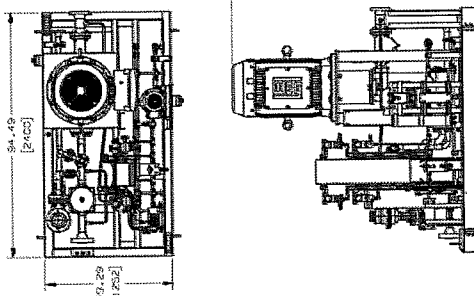
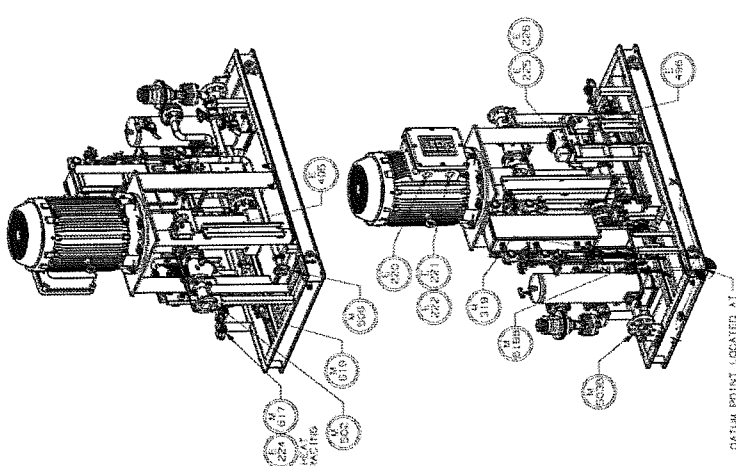
WATER INJECTION SKID

# MECHANICAL CUSTOMER CONNECTIONS

CONTN	SIZE	CONTN	TYPE	SERVICE	Y	INCH	Z	Y	MM	Z	MM
M219	0-50"	180	180	180	180	180	180	180	180	180	180
M220	0-50"	180	180	180	180	180	180	180	180	180	180
M221	0-50"	180	180	180	180	180	180	180	180	180	180
M222	0-50"	180	180	180	180	180	180	180	180	180	180
M223	0-50"	180	180	180	180	180	180	180	180	180	180
M224	0-50"	180	180	180	180	180	180	180	180	180	180
M225	0-50"	180	180	180	180	180	180	180	180	180	180
M226	0-50"	180	180	180	180	180	180	180	180	180	180
M227	0-50"	180	180	180	180	180	180	180	180	180	180
M228	0-50"	180	180	180	180	180	180	180	180	180	180
M229	0-50"	180	180	180	180	180	180	180	180	180	180
M230	0-50"	180	180	180	180	180	180	180	180	180	180
M231	0-50"	180	180	180	180	180	180	180	180	180	180
M232	0-50"	180	180	180	180	180	180	180	180	180	180
M233	0-50"	180	180	180	180	180	180	180	180	180	180
M234	0-50"	180	180	180	180	180	180	180	180	180	180
M235	0-50"	180	180	180	180	180	180	180	180	180	180
M236	0-50"	180	180	180	180	180	180	180	180	180	180
M237	0-50"	180	180	180	180	180	180	180	180	180	180
M238	0-50"	180	180	180	180	180	180	180	180	180	180
M239	0-50"	180	180	180	180	180	180	180	180	180	180
M240	0-50"	180	180	180	180	180	180	180	180	180	180

# ELECTRICAL CUSTOMER CONNECTIONS

CONTN	SIZE	CONTN	TYPE	SERVICE	Y	INCH	Z	Y	MM	Z	MM
E220	0-50"	180	180	180	180	180	180	180	180	180	180
E221	0-50"	180	180	180	180	180	180	180	180	180	180
E222	0-50"	180	180	180	180	180	180	180	180	180	180
E223	0-50"	180	180	180	180	180	180	180	180	180	180
E224	0-50"	180	180	180	180	180	180	180	180	180	180
E225	0-50"	180	180	180	180	180	180	180	180	180	180
E226	0-50"	180	180	180	180	180	180	180	180	180	180
E227	0-50"	180	180	180	180	180	180	180	180	180	180
E228	0-50"	180	180	180	180	180	180	180	180	180	180
E229	0-50"	180	180	180	180	180	180	180	180	180	180
E230	0-50"	180	180	180	180	180	180	180	180	180	180
E231	0-50"	180	180	180	180	180	180	180	180	180	180
E232	0-50"	180	180	180	180	180	180	180	180	180	180
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E236	0-50"	180	180	180	180	180	180	180	180	180	180
E237	0-50"	180	180	180	180	180	180	180	180	180	180
E238	0-50"	180	180	180	180	180	180	180	180	180	180
E239	0-50"	180	180	180	180	180	180	180	180	180	180
E240	0-50"	180	180	180	180	180	180	180	180	180	180



LIQUID FUEL FORWARDING SKID



GENERAL ARRANGEMENT  
TRENT 60 ALE

REV	NO	DESCRIPTION	DATE	BY	CHKD	APPD
1	1	ISSUED FOR CONSTRUCTION	1992			







# Rolls-Royce

## Global Engineering Reference

### GER 0070

Revision: 2

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## Grounding / Earthing Design and Application

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## EXECUTIVE SUMMARY

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

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

## POINT OF EMBODIMENT

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

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



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## 1 SCOPE

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

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

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

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

## 2 REFERENCE DOCUMENTS AND SPECIFICATIONS

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

## 3 DEFINITIONS

### 3.1 Bonding

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

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

### 3.2 Ground

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

---

### 3.3 Grounding Conductor

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

### 3.4 Neutral Conductor

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

### 3.5 Ground Electrode

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

### 3.6 Grounding Electrode System

3.6.1 The collection of all the grounding electrodes bonded together.

### 3.7 Equipment Grounding Conductor

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

### 3.8 Safety Ground

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

### 3.9 Instrument Ground

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

### 3.10 Intrinsic Safety Ground

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

### 3.11 Single Point or "Star" Ground

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

### 3.12 Multi-Point Ground

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

### 3.13 Electromagnetic Compatibility (EMC)

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

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## 4 THE PURPOSE OF GROUNDS

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

### 4.2 Safety

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

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

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

### 4.3 Noise Reduction

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

## 5 DESCRIPTION OF A GROUNDING SYSTEM

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

### 5.2 The Grounding Electrode System

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

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

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

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

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

### 5.3 The Bonding System

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

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

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

## 6 REQUIREMENTS FOR EQUIPMENT (SAFETY) GROUNDING

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

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

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

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

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

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

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

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

## 7 REQUIREMENTS FOR INSTRUMENT (CLEAN) GROUND

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

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

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

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

## 8 REQUIREMENTS FOR INTRINSICALLY SAFE (IS) GROUND

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

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

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

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

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

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

## 9 SPECIFIC BONDING REQUIREMENTS

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

## 10 SPECIAL CASE BONDING—ELECTRIC MOTOR DRIVES

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

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

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

10.2.2 Separate junction boxes for power and feedback are required.

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

## 11 STATIC BUILD UP PROTECTION

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

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

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

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

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

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

## 12 LIGHTNING PROTECTION BONDING

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

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

12.3 IEEE Std 1100-1992 section 4.6.4 states:

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

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

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

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

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

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

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

- See installation restrictions in Article 250.120 NEC



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

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



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

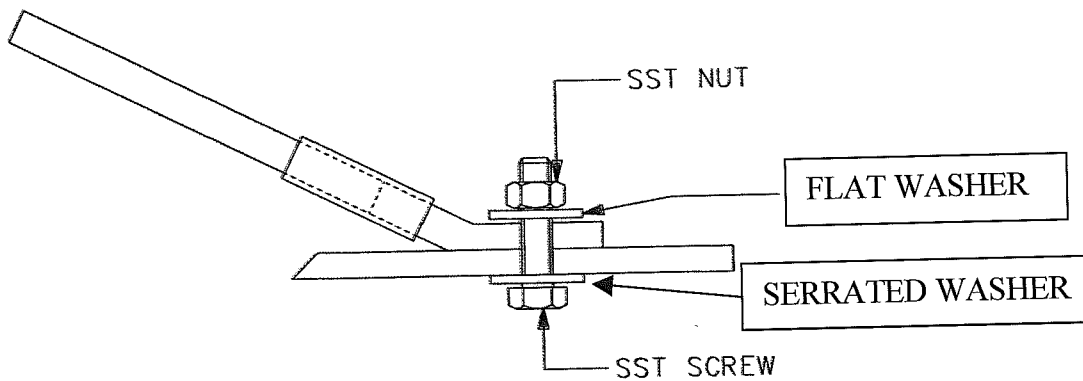


13.3      **Symbol for a “Special purpose” ground. Rolls-Royce Energy uses it to signify “intrinsically safe” or (IS) ground.**



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14 DETAILS OF GROUNDING/EARTHING ASSEMBLIES  
14.1 DETAIL A – TYPICAL GROUND/EARTH STRAP CONNECTION

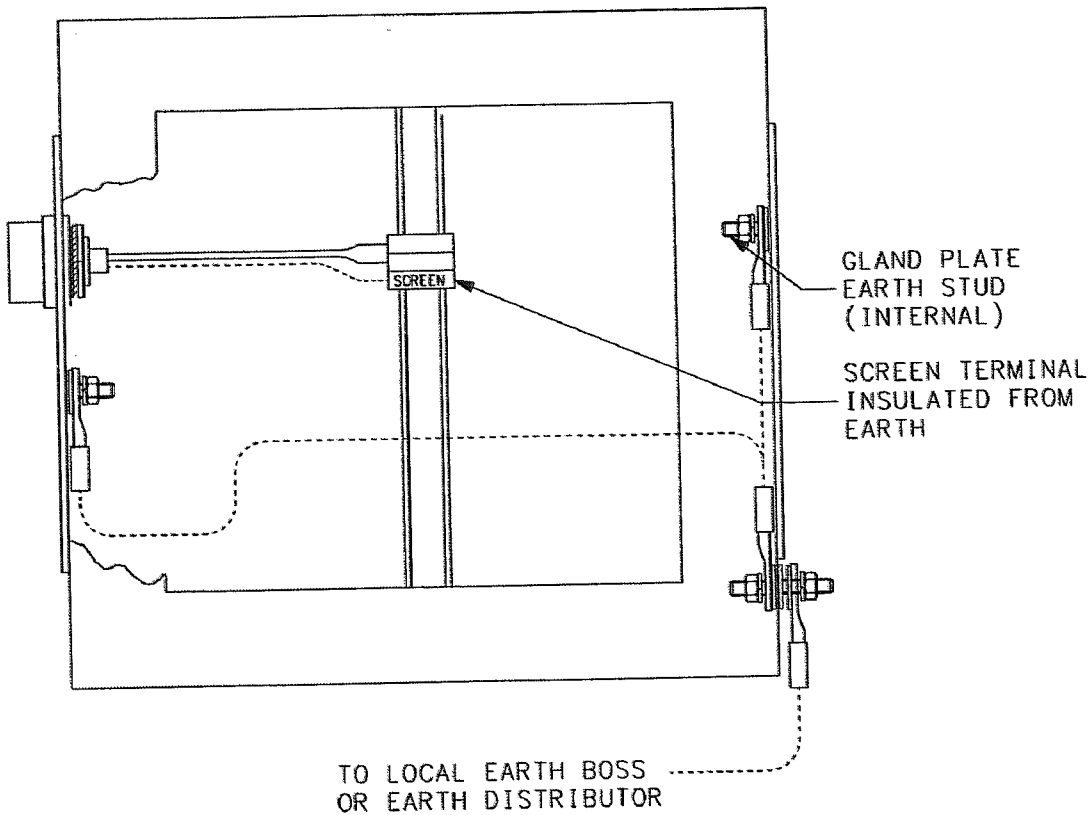


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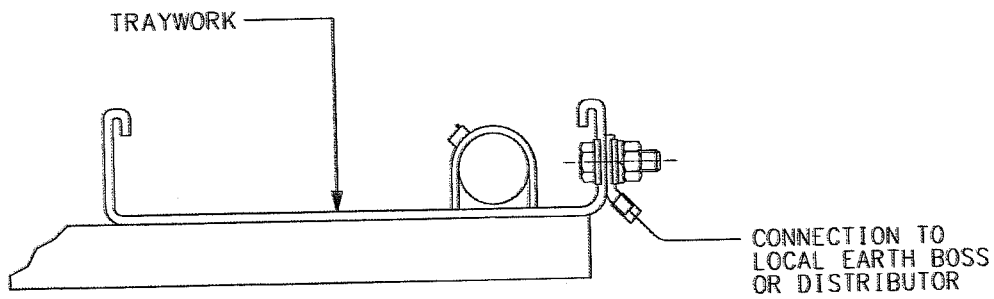
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## 14.2 TYPICAL JUNCTION BOX GROUNDING/EARTHING DETAIL

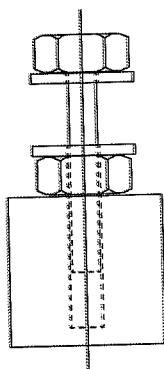


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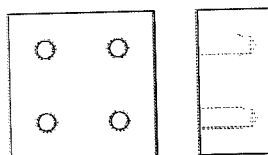
### 14.3 TYPICAL CABLE TRAY GROUNDING/EARTHING



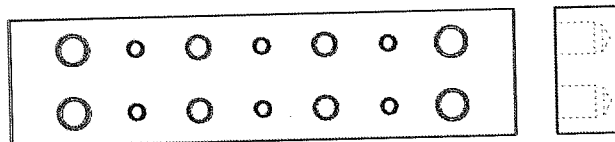
#### 14.4 TYPICAL SINGLE AND MULTIPLE POINT GROUND/EARTH CONNECTIONS



GROUND LUG - "EARTH BOSS" SINGLE POINT



Customer Ground/Earthing Block



Multiple Point Grounding/Earthing Block for Skid Mounting



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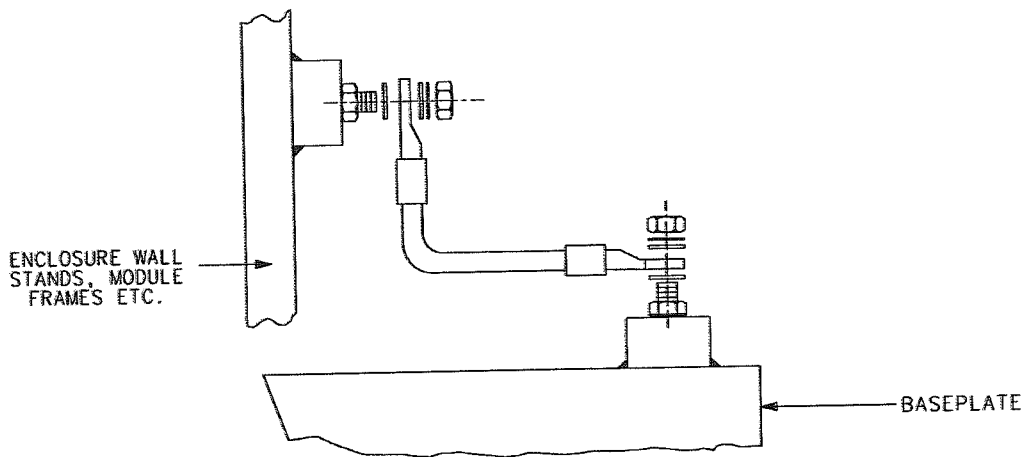
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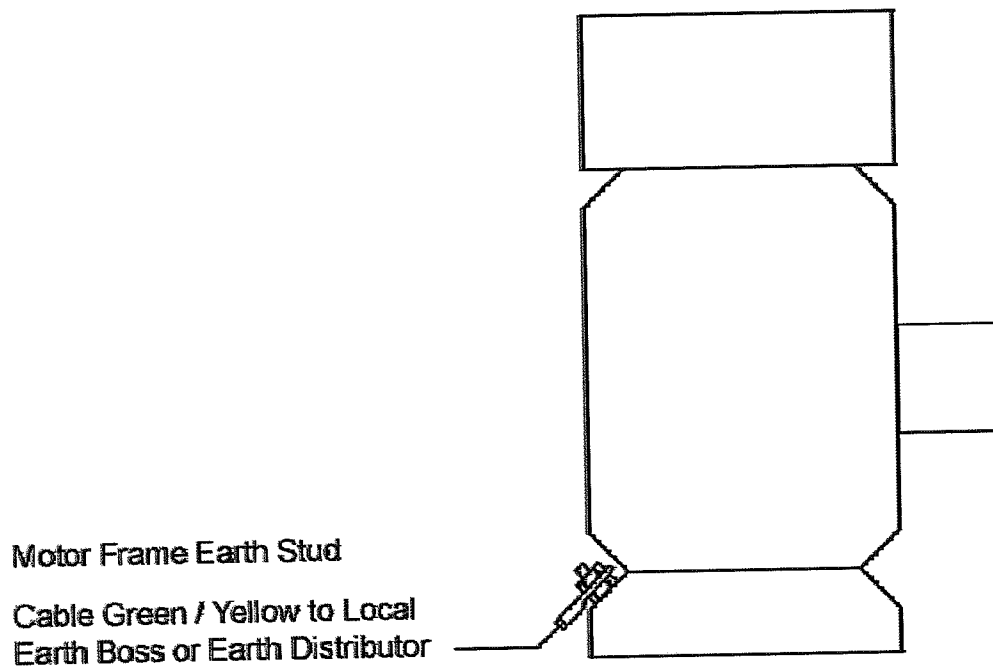
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14.5 TYPICAL GROUND/EARTH BOSS ASSEMBLY AND LOCAL BONDING



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14.6 GROUNDING/EARTHING OF MOTORS AND HEATERS





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## **Global Engineering Reference**

**GER 0144**

Revision: 1

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### **Water Quality Requirements for Cooling Water**

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## EXECUTIVE SUMMARY

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

## POINT OF EMBODIMENT

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

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



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## 1 SCOPE

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

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

## 2 REFERENCE DOCUMENTS AND SPECIFICATIONS

- 2.1 Water Treating, Section 11, Ecodyne MRM General Reference Paper, per G. Cash, VP, Ecodyne MRM, Rev 1974
- 2.2 GER 0023, Piping Specification
- 2.3 ANSI/API 662, 2nd Edition (Co-Registered with ISO), Plate Heat Exchangers for General Refinery Services, April 2002 (ISO 15547:2000)
- 2.4 ANSI/API 661, 6th Edition (Co-Registered with ISO), Air-Cooled Heat Exchangers for General Refinery Services, Feb. 2006 (ISO 13706-1)
- 2.5 Stainless Steel Advisory Service, SSAS Information Sheet No.4.92, Corrosion of Stainless Steels in Supply (Drinking) and Waste (Sewage) Water Systems

## 3 TYPES OF WATER SYSTEMS

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

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

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

## 4 GENERAL REQUIREMENTS

- 4.1 Chloride content of non-seawater used for cooling duty and hydrotest of austenitic SST pressure parts shall not exceed 50 ppm by weight (50 mg/kg).
- 4.1.1 Low levels of chloride (~ 1 ppm) limit bacterial fouling and stop any growth.
- 4.2 With seawater as cooling medium, refer to GER 0023 for standard piping materials .
- 4.3 pH value of water supply will vary depending upon water treatment process. Slightly alkaline (pH 9) is normal.
- 4.4 Total dissolved solids shall be minimized by suitable water treatment using ion exchange resins or similar.
- 4.5 Water/glycol mixes can be used to reduce freezing point, depending upon expected contract conditions.

## 5 WATER DELIVERY FILTRATION

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

## 6 WATER TEMPERATURE LIMITS

- 6.1 Water supply temperature (minimum without antifreeze) is to be 5°C (41°F); otherwise it shall be 5°C above freeze point. Maximum supply temperature is 35 °C (95°F) which will require large flow rate; supply temperature should be as cool as possible within limits.
- 6.2 Re-circulatory water systems commonly have flow control devices (typically on cooler discharge) to maximize water discharge temperature. These can be orifices or valves. By maximizing the discharge temperature, flow quantity is minimized, which increases overall efficiency of the cooling system. Customer supplied cooler will remove heat from returned water.
- 6.3 Water discharge temperature in a through/open loop system using seawater should be limited to below 45°C (113°F) to suppress algae growth at discharge point.

## 7 WATER SUPPLY PRESSURE & FLOW RATE

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



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Rolls- Royce  
Gas Turbine Package  
Site Emissions &  
Enthalpy Testing

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





## 1.0 Introduction

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

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

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

## 2.0 Process Description

### Required Test Instrumentation

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

## General Information/Data

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

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

40CFR 60, Method 10 includes:

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

Hydrocarbons



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## General Information/Data

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

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

40CFR 60, Method 25A includes:

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

### Exhaust Enthalpy

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

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

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

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

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

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

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

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

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



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Purge Valve  
Unit Valves  
Station Valves  
Fuel Valves

### Final Report Format

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

#### Title Page:

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

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

##### Summary:

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

#### Body of Report:

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

#### Appendices

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

Appendix 2 Reference Sheet:  
identifies all personnel present during testing

- (i) name
- (ii) title
- (ii) company name and address

phone/fax number



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*Rolls-Royce Energy Systems  
Standard Test Procedure*

Issue 1

**Authorisation and Change History**

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

**Reason for issue:**

Issue	Summary	Date
1	Initial Issue	15 Dec 2005

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

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

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

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

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