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## 1. SCOPE

This specification covers the engineering requirements for the design, manufacture, testing at works and supply of diesel generators.

## 2. CODES AND STANDARDS

The Supplier's Works shall comply with the current and national statutory regulations, codes and standards applicable in the Philippines as stated in 1711-TS-036 Engineering Specification - Applicable Codes and Standards.

Where these are not applicable or available, then IEC standards or relevant appropriate Australian Standards shall be used.

However, in order to allow flexibility in design and sourcing of equipment, standards shall be applied with the option of vendors to offer alternatives to other standards providing approval is obtained from the Purchaser.

In the case of conflicting information the following precedent shall apply:

- National Statutory Regulations.
- IEC Standards.
- Australian Standards.
- ISO Standards.
- British Standards

## 3. CLIMATIC AND AMBIENT CONDITIONS

At the Project site, rainfall has been monitored daily since May 1989. The mean annual rainfall calculated for the site is 2929 mm.

Electrical equipment and installations shall be designed to operate under the extremes of conditions for the location within which they are installed and shall be suitable for the design ambient temperatures:

- Minimum: - 5 °C
- Maximum: + 45 °C

The site of the process plant is approximately 700 m above the sea level.

Equipment will be required to operate continuously at full load for 24 hours per day, 365 days per year under the climatic conditions detailed in the data sheets. All equipment shall be designed to perform this duty safely and without being attended.

## 4. WORK INCLUDED

The scope of work includes, but is not necessarily limited to supply of the enclosed diesel generators as follows:

- 1650 ekW, 13.8 kV 60 Hz

**5. WORK EXCLUDED**

The following items are excluded from the scope of work:

- a) Foundations.
- b) Hold-down or mounting bolts, nuts and washers at concrete foundations / structural steel.
- c) Installation at site.
- d) Supply, installation and connection of all power, control and instrumentation cabling outside the battery limits.

**6. SPECIAL REQUIREMENTS**

- The diesel generator sets must be as fully enclosed and ready for outdoor installation on site.
- The diesel generator sets must have their own battery and a charger for start.
- 380/220 V distribution board must be designed by the Vendor.
- The diesel generator sets must be of a size to enable easy lifting for road and sea transport.
- Provide layouts of each set with equipment drawing to scale and showing location of each panel.
- Provide all type test certificates type test certificates.
- Must be designed to facilitate inspection and maintenance.
- Protection devices must latch.
- Provide list of items that will be packed for transport separately. Provide details of how will be packed.
- Observe the specification for wire, cable and core colours.
- Must use appropriate lugs and connection/terminations. Control wiring, to use tunnel type terminals and pre-insulated pin lugs. Separate pin lugs for each core.
- Must submit a labeling schedule for approval before labels are made.
- Must provide drawings as per VDDR. Includes drawings showing "as built".
- Must recommend and implement settings for all protection relays.
- Provide signage.
- Fire extinguishers.

## 7. DESIGN AND CONSTRUCTION

### 7.1 General

The Supplier shall provide skid-mounted, compression ignition, diesel engine driven generating sets complete with governing systems, local engine instruments, exhaust system, cooling system and generator control switchboard. Mount all equipment within a 2.0 mm ZA sheet steel clad acoustic enclosure.

Each generating set shall have the minimum ratings indicated in Appendix A - Generator Data Sheet at the specified reference conditions when installed on site.

The diesel generators and auxiliary equipment shall be capable of continuous operation at rated output under the specified environmental conditions, and shall have a 10% overload capacity for one hour every twelve hours.

The diesel generator units shall be capable of continuous operation without any detrimental effect on general performance or maintenance requirements at an output not greater than 50% of its continuously rated output.

When the loads to be supplied by the diesel generator units are specified, with the rating of the diesel generator unit to be determined by the seller, the selected rating shall be such as not to exceed a 10% volt drop on starting the largest motor with all other specified equipment running.

The mass system comprising the diesel engine, flywheel and alternator shall not have a critical speed within  $\pm 15\%$  of synchronous speed.

### 7.2 Diesel Generator Enclosure

The diesel generator units shall be totally enclosed in an acoustic enclosure suitable for outdoor installation, designed to operate with all access doors and panels closed, and mounted on an integral unit base frame suitable for mounting on minimum foundations. Anti-vibration mountings shall be provided to prevent the transfer of vibration from the base frame to the foundations.

The base frame shall be capable of maintaining diesel engine and alternator alignment and accommodating the loads generated under fault conditions without relying on foundation block stiffness.

The base frame of the unit shall be drilled for foundation bolts, and the enclosure shall be fabricated with lifting points in the base frame or at roof levels.

The enclosure shall be of fabricated sheet steel internally stiffened and lagged with a fire resistant, sound absorbing material and equipped with the following features:

- lockable, hinged access doors and covers affording ready access for complete inspection and in situ maintenance
- an external 10A GPO of a high impact plastic, weather and hose-proof type, with screw cap and flat pins
- an external welding outlet, cast iron galvanised weatherproof interlocked switch plug combination with screw cap, 5 pin, 32A
- designed to have simple disconnection of incoming pipes and cables to facilitate the removal of the complete unit from site

Walk-through type enclosures shall have the following additional features:

- ladder to provide access to the top of enclosure
-



- fire detection system
- internal lighting using protected industrial fluorescent lamps which shall be adequate for inspection purposes
- an emergency internal light adequate for black start conditions

Suitable facilities shall be provided for the entry of cables into the enclosure.

All openings shall be fitted with guards and/or screens to prevent the entry of vermin and insects.

### 7.3 Noise Level

The diesel generator unit, including exhaust and induction air, shall be noise attenuated such that noise levels do not exceed 75 dBA at 5m.

This noise level shall be achieved under the following conditions:

- Ambient noise level of 45 dB(A)
- Generator running at full load
- All enclosure access panels in place

### 7.4 Labelling

Each diesel generator unit shall be fitted with an engraved traffolyte main label (black lettering on a white background) with the equipment number and title in minimum 75 mm high letters.

In addition, every device, including terminals, terminal strips, fuses, switches, test blocks, indication lamps, relays and other equipment, shall be identified by a label fixed near the device and oriented so that it is readable from the appropriate access door. The label shall give both the device title or function and a unique alphanumeric identification code.

All device labels, other than proprietary legend and escutcheon plates on devices, are to be engraved from white/black/white laminated engraving material. External labelling shall be fixed by stainless steel threaded screws, rivets are not permitted. Labels longer than 30 mm shall have clearance fixing holes and shall have some freedom of movement to allow differential expansion of label and mounting. Where labels are mounted on standoffs, they shall be suitably backed to prevent breakage.

Label letter height shall be as shown on the Ausenco drawing No. 1711-00-E-0030/31

Warning labels shall be provided as necessary.

Warning and safety labels other than the above shall be white letters on a red background.

## 8. MECHANICAL AND CONSTRUCTIONAL REQUIREMENTS

### 8.1 Materials

All materials incorporated in the manufacture of the equipment and all bolting/fasteners shall be new with manufacturer's compliance certificates provided.

### 8.2 General mechanical requirements

Mechanical equipment requirements shall generally be as specified by Engineering Specification 1711-ES-043 – General Mechanical Requirements subject to contract pre-award discussions and negotiations.

### **8.3 Testing and inspection – General requirements**

#### **8.3.1 Acceptable testing authority**

All materials testing (chemical, tensile, impact, microstructure, and hardness) shall be undertaken by a National Association of Testing Authorities (NATA) registered testing authority.

#### **8.3.2 Record of results and reports**

Record of results and reports shall be in accordance with the recommendations and/or requirements (both mandatory and non mandatory) of the standard applicable to the testing and inspection methods employed.

Record of results and reports shall also, as a minimum, be included in the Manufacturer's Data Report (MDR) immediately upon their issue and be immediately issued to The Engineer for review and acceptance where this is specified as a requirement by the Vendor Document and Drawing Requirements (VDDR).

All records shall be traceable with respect to the following;

- (a) location
- (b) manufacturer / operator / welder
- (c) inspector / NDT operator and associated qualifications
- (d) date and time of inspection
- (e) full definition of the procedure used with reference to applicable standards
- (f) full description of result (to be provided with the aid of sketches, photographs, chart printouts etc.)

#### **8.3.3 Inspector qualifications**

Inspector qualifications shall be in accordance with the requirement or recommendations of the code or standard applicable to the task or works.

Where the Supplier/Contractor is not AS/ISO 9001 certified, inspectors shall be independent of the Supplier/Contractor and works sub contractor and their qualifications and appointment shall subject to review and acceptance by The Engineer.

In cases where inspector qualifications are not defined or specified by the standard or code applicable to the task or works, inspector qualifications shall also be subject to review and acceptance by The Engineer.

### **8.4 Steel fabrications**

The Supplier/Contractor is to provide their standard specifications/procedures for steel fabrication for evaluation and review by The Engineer.

As a minimum, it is expected that this specification clearly indicates the following:

- (a) Material specification and fabrication procedures
- (b) Material testing and inspection requirements
- (c) Applicable welding standards
- (d) Stress relieving / heat treatment specification and procedures
- (e) Profile improvement specification
- (f) Testing and inspection for both raw fabrications and finish machined fabrications including;
  - Inspector qualification
  - Visual inspection criteria and acceptance level definition

Magnetic particle testing criteria and acceptance level definition

Radiographic and/or ultrasonic testing criteria and acceptance level definition

Dimensional checks

## **9. DIESEL ENGINE AND AUXILIARY EQUIPMENT**

### **9.1 Diesel Engine**

The diesel engine shall be a direct injection compression ignition type.

The nominal speed of the engine shall not exceed 1800 rpm.

Each diesel engine shall be provided with the following:

- A self-contained cooling system rated for the specified ambient temperature, and heat exchangers as required for charge air and lubricating oil cooling. The cooling system shall have provision to prevent over-cooling during cold weather and over-heating in the hot weather.
- Unless otherwise specified the diesel generator units shall be water cooled with a radiator and engine driven fan. Water cooled systems shall include a thermostatically controlled engine cooling water bypass system for rapid engine warm up, be totally sealed with a pressure relief cap and drain, have the addition of a corrosion inhibitor, and shall be fitted with suitable valves for engine and radiator flushing.
- The radiator shall have a copper core and shall be sized to have 15% spare heat transfer capacity over and above the maximum engine heat rejection. Protective grilles shall be provided on the air discharge side of the radiator to protect the core from damage, and around the radiator fan for personnel protection.
- Radiator fans shall be provided as necessary to exhaust air from the diesel generator enclosure.
- An air intake system with at least two stages of heavy duty industrial, dry type air filters.
- An exhaust gas pipe system fabricated from mild steel with a thickness not less than 2 mm. Connections shall be flanged using heat resistant gaskets. All necessary supports shall be provided.
- A flexible joint shall be provided to prevent excessive loads and vibration being transmitted between the engine and exhaust ducting. The joint shall be manufactured from stainless steel.
- A residential silencer shall be provided to reduce noise to the specified levels and shall be arranged such that the silencer weight is not supported by the engine and no thermal stress from the exhaust system is imposed on the engine.
- The exhaust outlet shall be arranged to minimise noise generation and to prevent entry of dust and rain or entrainment of exhaust gases into the engine air intake or cooling systems.
- All internal exposed exhaust pipe surfaces shall be insulated. Insulation shall be suitably rated mineral wool or fibreglass. Cladding shall be manufactured with rolled edges from 1 mm zincalume sheet and shall be fixed with corrosion resistant self tapping screws.
- An engine-mounted fuel tank of at least 12 hours capacity at full load fitted with level gauge, float valve and filter on the fuel inlet. The fuel tank shall be complete with vent piping and cap, overflow protection and drain valve. The tank shall not be mounted over the engine or generator.
- A manual shut-off valve and filter shall be provided in the supply line to the engine fuel pump. The filter shall be the replaceable cartridge type.

- The fuel system shall incorporate facilities to overcome fuel starvation due to high ambient temperatures.
- An automatic lubricating oil level regulator and lubricating oil make-up tank. The lubricating oil system shall be self priming and shall incorporate an automatic pre-lube cycle where necessary with the pre-lube pump motor operating from 24 V DC.

A full flow filter with replaceable element shall be provided along with a graduated oil level indicator (dipstick).

- An oil cooler shall be provided for all air cooled engines and where necessary for water cooled engines.
- Suitable connection facilities for oil drainage and refill from portable lube oil transfer pumps shall be provided along with a readily accessible drain valve.
- A steel drip tray shall be provided under the engine to catch all fuel and lubricating oil spillage. It shall be possible to remove and replace the trip tray with the engine running.
- Electric start equipment complete with batteries and battery charging equipment. The starting system shall be based on a 24 V DC battery system with speed sensing to disconnect the starter motor automatically upon the engine firing and reaching a suitable operating speed.
- Batteries shall be maintainable lead acid type suitable for engine cranking duty and of sufficient capacity to ensure that the voltage during the running of the starter motor does not fall below a level sufficient to operate the controls.
- A static type 220 V AC battery charger shall be provided, fitted with an ammeter. The battery charger shall be complete with a weatherproof GPO to provide a power supply for the charger, the GPO being connected to an external power supply by others.
- Engine mounted instruments:
  - lube oil pressure gauge
  - lube oil temperature gauge
  - jacket water temperature gauge (if water cooled)
  - speed
- Panel mounted instruments:
  - lube oil pressure gauge
  - lube oil temperature gauge
  - jacket water temperature gauge (if water cooled)
- Alarm switches:
  - low lube oil pressure
  - high lube oil temperature
  - high jacket water temperature
- Automatic shutdown:
  - low lube oil pressure
  - high lube oil temperature
  - high jacket water temperature (if water cooled)
  - engine overspeed
  - any other safety shutdown devices required to permit unattended operation
- Governor:
  - an electronic governor capable of controlling speed in accordance with class A1 of AS 4594. The governor shall be fail safe and shall shutdown the

engine on loss of control power supply. All governor system components not mounted directly to the engine shall be mounted in a steel weatherproof control panel.

## **9.2 Fuel**

The engine shall operate on standard Philippine diesel fuel – for product data sheet refer to Appendix B.

## **10. GENERATOR AND EXCITATION SYSTEM**

### **10.1 Generator**

The generator shall be three phase, four wire, self-excited, self-regulating, force ventilated, salient pole, of the brushless type, direct coupled to the engine with a single support bearing arrangement.

Low voltage generator shall have the neutral earthed.

The generator shall be air cooled; screen protected (cooling system classification IC01) with Class F insulation operating with a Class B temperature rise and shall be tropicalised varnish impregnated. The generator characteristics shall match the engine torque curve. The generator shall have fully interconnected damper windings.

Where necessary to prevent condensation under the environmental conditions specified, a switched anti-condensation heater shall be provided.

### **10.2 Generator Performance Requirements**

The generators shall be suitable for continuous operation at rated output under the environmental conditions specified, and shall have a 10% overload capacity for one hour every twelve hours.

### **10.3 Generator Monitoring and Protection**

The generators shall be provided with complete electrical protection relay(s) as recommended by the manufacturer.

### **10.4 Trip Alarm Conditions**

Provide the following the following alarm signals:

- Emergency stop
- Controller failure
- Low control voltage
- High engine cooling water temperature
- Low engine lubricating oil pressure
- Overspeed
- Underspeed
- Low fuel level (Trip level)
- Generator fail to start

Provide a separate LED type, red coloured, illuminated indicator on the control panel for each alarm and a common audible indicator with mute. Activation of any alarm shall cause the alarm to be annunciated and the engine to shut down immediately by de-energising the fuel solenoid and locking out the generator.

Suppress subsequent trip alarms so that only the initial trip alarm is displayed.

The generator shall only be able to re-start when the alarm condition reset. This shall occur when the parameter returns to acceptable levels and the Reset button pressed.

Resetting the alarm condition shall also reset the mute.

### **10.5 Shut Down Alarm Conditions**

Provide the following the following alarm signals:

- Alternator overcurrent
- Loss of excitation

Provide a separate LED type, red coloured, illuminated indicator on the control panel for each alarm and a common audible indicator with mute. Activation of any alarm shall cause the alarm to be annunciated and the engine to perform a sequenced shutdown and lock out the generator. A sequenced shutdown shall follow the same sequence as a shutdown following restoration of the main supply.

The generator shall only be able to re-start when the alarm condition reset. This shall occur when the parameter returns to acceptable levels and the Reset button pressed.

Resetting the alarm condition shall also reset the mute.

### **10.6 Warning Conditions**

Provide the following warning signals:

- High engine cooling water temperature
- Low engine lubricating oil pressure
- Low fuel level (Warning level)
- Starting battery low voltage
- Control battery low voltage
- Starting battery charger fail
- Control battery charger fail

Provide a separate LED type, amber coloured, illuminated indicator on the control panel for each warning and a common audible indicator with mute. Activation of any warning shall cause the warning to be annunciated. The generator shall continue to run.

Operation of the mute shall not prevent the audible indicator from sounding for subsequent alarms and warnings. However, should the same warning condition re-occur when muted the audible indicator shall not sound.

The warning condition shall be reset when the parameter returns to acceptable levels and the Reset button pressed.

Resetting the warning condition shall also reset the mute.

The following basic protection functions are expected to be included:

- Overcurrent,
  - Instantaneous overcurrent,
  - Over/Undervoltage
  - Over/Underfrequency
  - Overload
  - Stator earth fault,
  - Instantaneous stator earth fault,
  - Phase unbalance,
  - Reverse power,
-

- Field failure, and
- Differential, where justified.

### **10.7 Generator Excitation System**

The excitation system shall be of the brushless self-excited type with the regulator power supply and reference voltage being taken from the generator output voltage. Field build-up shall be automatic.

The excitation system shall be such as to maintain a minimum of three times full load current for a minimum of three seconds in the event of a short circuit.

The excitation system shall comprise:

- the exciter
- automatic voltage regulator
- potential transformers
- current transformers.

The exciter shall be of the rotating brushless type with shaft mounted rectifier assembly. The exciter shall have Class F insulation with Class B temperature rise and be of the enclosed ventilated type having the same degree of protection as the generator enclosure.

The automatic voltage regulator (AVR) shall be of the solid state type unless otherwise specified.

Voltage droop, voltage level and voltage gain shall be fully adjustable behind the control panel, preventing adjustment by unauthorised personnel.

The AVR shall maintain the generator output voltage within  $\pm 2.5\%$  of nominal setting from full load to 10% overload, and at any power factor between unity and 0.8 lagging, and shall respond rapidly, with minimum over-shoot, to the current associated with direct-on-line starting of large squirrel cage motors.

### **10.8 Generator Bearings**

The generator bearings shall preferably be ball or roller type bearings, grease lubricated, of standard metric sizes, interchangeable with other manufacturer's bearings of the same size and type.

All bearing housings shall be equipped with a pressure relief greasing system and pressure nipples. The housing shall be equipped with suitable seals to prevent moisture and dust from entering through the shaft opening.

Provision shall be made to prevent damage to the bearings by circulating shaft currents by the inclusion of insulation between one bearing assembly and the generator frame. All metallic connections to this bearing shall also be insulated.

### **10.9 Temperature Detectors**

Embedded temperature detectors shall be provided to monitor the temperature of the generator windings and gearings. The high temperature shall initiate an alarm and trip the generator in the event of over-temperature occurring.

## **11. GENERATOR TERMINAL BOXES**

Separate terminal boxes shall be provided for the generator phase and star point connections and for the temperature sensing devices.

The terminal box for the phase and star point connections shall be large enough to accommodate the current transformers associated with differential protection equipment when specified, shall have an IP 55 classification protection and shall be sealed between the terminal box and the generator frame. Elastimold or equivalent connections between the generator and high voltage cables are preferred.

Blank, removable, non-magnetic gland plates shall be provided.

Each terminal box shall be fitted with an internal earthing bolt and stud of adequate dimensions for connection of an earthing cable.

## 12. INSTRUMENTATION AND CONTROL

All controls and equipment for control and monitoring of the diesel generator units shall be incorporated in a control panel installed in the diesel generator enclosure, the control panel being mounted on anti-vibration pads.

All electrical equipment and terminations associated with the generator output voltage shall be located within a separate enclosure to that associated with the diesel generator control and instrumentation equipment.

Engine starting shall be by depressing a start pushbutton mounted on the control panel. Automatic start-up of the engine shall be provided.

Normal engine stopping shall be by the operation of a stop pushbutton mounted on the control panel. Normal engine stop shall initiate a cooling down timer which allows the diesel engine to run unloaded for a time period specified by the diesel engine manufacturer.

Emergency shutdown of the diesel generator shall take place when any of the automatic shutdown conditions occur, or the emergency stop pushbutton on the diesel generator control panel is operated. The diesel engine shall be stopped without delay by stopping fuel entering the engine.

Each diesel generator control panel shall be fitted with an ammeter and selector switch, a voltmeter and voltage selector switch, a frequency meter, power factor and an hour run meter.

An alarm annunciation system shall be provided on the control panel, comprising illuminated pilot lights or similar, for all automatic shutdown conditions and alternator over-temperature trip (where provided). The alarm conditions shall lock-out the engine and prevent restart until reset by means of a reset pushbutton.

The control equipment shall use, as far as practical, solid state standard product modules. The equipment may combine several functions within any module in line with any standard product range.

Each diesel generator control panel shall have the facility to provide the following signals to a remote panel by means of voltage free contacts:

- engine on
- engine off
- engine fault.

## 13. TESTING AND INSPECTION

During the course of manufacture, all work will be subject to progressive inspection and expediting by the purchaser or his representative.

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Not less than seven days' notice of all tests shall be given to the purchaser in order that he may be present if he desires. Duplicate copies of the seller's records of all tests and type test certificates shall be furnished to the purchaser.

### **13.1 Routine Tests**

Each item of equipment shall be subjected to and satisfactorily withstand the routine tests specified in the relevant Australian Standard.

Prior to the commencement of testing, all equipment and component adjustments shall be made, including but not necessarily limited to:

- governors
- AVR's
- instruments and switches.

Settings shall be made under the specified load conditions and allowing for the actual reactive load component.

The diesel generator unit shall be full load tested complete with the exciter, AVR, radiator, generator and auxiliaries that will be installed on site, and operating with the fuel specified. The test program shall include at least the following, in accordance with the requirements of AS 4594:

- temperature rise across the complete cooling water system
- alternator and exciter temperature rises
- vibration test of generator at rated speed
- response checks of AVR and frequency control with sudden load shedding and sudden load application
- noise level measurement
- over-speed shut-down function test
- measurement of net fuel usage at 25%, 50%, 75% and 100% of generator rated output
- capability of starting equipment
- exhaust emissions
- waveform deviation
- routine testing of all switchgear assemblies, circuit breakers and control gear
- primary three phase current injection testings of all protection and metering instruments
- the complete functional testing of all equipment including indication, alarms, controls etc.

**APPENDIX A ENGINEERING SPECIFICATIONS AND DATA SHEETS**

<b>SPECIFICATION NO.</b>	<b>TITLE</b>
1711-ES-005	SURFACE PROTECTION
1711-ES-022	PREFERRED ELECTRICAL EQUIPMENT LIST
1711-ES-023	ELECTRICAL EQUIPMENT SUPPLIED WITH PACKAGES
1711-ES-030	PACKAGING AND TRANSPORT OF GOODS
1711-ES-036	APPLICABLE CODES AND STANDARDS
1711-ES-039	EQUIPMENT TAGGING
1711-ES-042	SITE DATA

## APPENDIX B PETRON INDUSTRIAL DIESEL FUEL DATA SHEET



## Product Data Sheet

## PETRON INDUSTRIAL DIESEL FUEL

### DESCRIPTION

PETRON INDUSTRIAL DIESEL is a "dual purpose" fuel that is recommended as a boiler fuel in domestic or light industrial installations with pressure jet burners and as a diesel fuel for off-the-highway equipment such as stationary diesel engines, farm tractors, construction equipment, railway and marine engines.

### APPLICATION

- For industrial, railway and marine diesel engines, farm tractors, construction equipment, boilers, furnaces and kilns.

### TYPE/QUALITY LEVEL

- Distillate fuel

### AVAILABLE PACKAGES

- Bulk
- 210-liter drum

### TYPICAL CHARACTERISTICS

Density at 15°C, kg/m <sup>3</sup>	845.4
Color, ASTM	5.0
Viscosity at 40°C, cSt	3.312
Flash Point, °C, PMCC	75
Pour Point, °C	-6
Cloud Point, °C	0
Sediments & Water, Vol. %	0.05
Sulfur, Mass %	0.28
Copper Corrosion, 3 hrs. at 100°C	1a
CCR on 10% Bottoms, Mass %	0.10
Ash, Mass %	0.003
Distillation: °C	
50% Recovery	259
90% Recovery	363
Caloric Heating Value, HHV, BTU/lb.	19,600
LHV, BTU/lb.	18,414