TM2500+ Power for Hydraulic Fracturing

by

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Fracking 101

[Diagram of hydraulic fracturing process with labels and captions]

Current Technology Hydraulic Fracturing Site

- Freshwater Tanks
- Slurry Blender
- Chemical Storage
- 16 Pump Trucks
- Frac Trailer
- Company Man Trailers
- Proppant (sand)
- Freshwater Pit
- Freshwater Tanks
- Wellhead
- Wireline Rig

Michigan Department of Environmental Quality
Current Fracking Power Concerns

- “Hot fueling” safety
- Drill pad footprint, traffic
- Diesel CA$1.10/L – CNG CA$0.85 DLE*
- 60% max NG substitution rate
  - Pipeline quality NG/LNG
  - Less NG substituted if field gas
  - NG manifolds to multiple diesel trucks
  - Spark ignition recip’s too heavy

*Diesel Liter Equivalent
Current Technology Equipment

Evolutionary Well Services Equipment
EWS Demonstration Hydraulic Fracturing Site

Lethbridge, Alberta

A) Frac Pump Modules
B) Blender
C) Mobile Data Van
D) Chem Addition Mod
E) Blender Mtr Contrl
F) Sand Conv Belt Mod
G) Sand Storage Mod
H) GE TM2500+ GTG
I) Pump Mtr Contrl
Material Handling
Mobile Modular Design

Electric Motor
Fracturing Pump
Blender
Control Building
Compressed Natural Gas (CNG) Fuel

Natural gas from the first well then fuels subsequent wells

Six hours endurance at 50% power for the first well
TM2500+ Gas Turbine
GE TM2500+ Design

Main Trailer
- Transportation Jeep
- KM2500+
- Generator
- Switchgear
- Transportation Stinger

Auxiliary Trailer
- Trailer Gooseneck
- Inlet Filter Assembly
- Exhaust Stack
- LM2500+
- Lube Oil Coolers
- Turbine Enclosure Fire Suppression
- Hydraulic Starter
- Fuel/Water Pumps
- Control Room & Battery Room
Primary Components

GE LM2500+ Gas Turbine
- Zero staged version of the LM2500
- 2000+ LM2500 turbines worldwide
- More than 67M operating hours

Brush Electrical Generator
- Air-cooled generator, brushless excitation
- Suitable for Class 1, Group D, Div. 2 areas
- 60Hz (13.8kV) and 50Hz (11.5kV) operation
- Rated at 32,550 kVA @ 0.90pf in ISO conditions
LM2500 vs. LM2500+ GT Centerlines

- Stage Zero Blisk
- New Compressor Front Frame & Forward case
- Beefed up LPT disks & rear shaft
- Re-designed HPT, TMF & LPT Case
- Re-designed LPT airfoils
- Re-designed CDP Seal

~33 cm (~13 inches)

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TM2500+

- Up to 38% efficiency @ 100% load
- 10 min fast start
- Small Footprint 24m x 7m (78’ x 21’)
- Fleet availability
- Capable of SC application
- Offering turnkey solutions
- Blackstart capability

<table>
<thead>
<tr>
<th>Attributes</th>
<th>TM2500+</th>
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<tbody>
<tr>
<td>Power Output ISO (MW)$^1$</td>
<td>31</td>
</tr>
<tr>
<td>SC Efficiency (%) $^1$</td>
<td>36.0</td>
</tr>
<tr>
<td>Nox Emissions (ppm)$^1$</td>
<td>25</td>
</tr>
<tr>
<td>Emissions Control</td>
<td>Water</td>
</tr>
<tr>
<td>Footprint</td>
<td>24m x 7m</td>
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<tr>
<td>Noise Level</td>
<td>87 db</td>
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<tr>
<td>Fuel</td>
<td>Dual</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>90k</td>
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</tbody>
</table>

References:
1) All Power, heat rate, and efficiency @ ISO conditions with water injection at 60 Hz, natural gas fuel
Customer Interface Requirements*

Fuel

- Gas supply pressure is 36 bar (+/- 1) (520 (+/- 20) PSIG) at a rate of 337 GJ/hr (320 MMbtu/hr)
- Liquid Fuel (diesel) supply pressure is 2 bar (+/-0.6), (30 (+/- 10) PSIG), up to 150 LPM (40 GPM) (max)

Water (for NOx suppression)

- Minimum supply pressure is 1 bar (15 PSIG) up to 106L (28 GPM) (max)

Foundation

- Site levelness less than 2m per 30m
- Adequate access/space for maneuvering the trailers

*These requirements represent general needs of a standard TM2500+ installation. Actual requirements could vary based on site location, site conditions, local ambient conditions, unit configuration, and many other factors.
Small details make a big difference!
Conventional arrangement for a 15 MW site
40% less area required for power train and pumps using the EWS/GE System
# System Comparison

<table>
<thead>
<tr>
<th></th>
<th>Diesel Truck Pumps</th>
<th>EWS Gas Turbine System</th>
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<tbody>
<tr>
<td>Prime Movers (15 MW)</td>
<td>16 Diesel Trucks</td>
<td>1 TM2500+</td>
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<tr>
<td>Pump Units</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Fuel</td>
<td>Diesel</td>
<td>#2 Diesel/NG/CNG/LNG</td>
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<tr>
<td>Power Efficiency</td>
<td>38.9%</td>
<td>36.8% (incl -1% elec mtr)</td>
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<tr>
<td>Noise (max pwr)</td>
<td>105 dB*</td>
<td>90 dB</td>
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<tr>
<td>Nox Emissions</td>
<td>52.5 Kg/hr Diesel (dry)**</td>
<td>70.4 Kg/hr #2 Diesel (dry)</td>
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<td></td>
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<td>43.3 Kg/hr NG (dry)</td>
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<td></td>
<td></td>
<td>13.0 Kg/hr #2 Diesel***</td>
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<tr>
<td></td>
<td></td>
<td>7.6 Kg/hr NG***</td>
</tr>
<tr>
<td>Personnel</td>
<td>1 Controller</td>
<td>2 Controllers</td>
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<tr>
<td></td>
<td>16 Pump Operators</td>
<td>1 Gas Turbine Operator</td>
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<tr>
<td>Power/Pump Footprint</td>
<td>778 sq m (8,375 sq ft)</td>
<td>464 sq m (5000 sq ft)</td>
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<tr>
<td>People Infrastructure</td>
<td>5x</td>
<td>1x</td>
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</tbody>
</table>

* Engine surface noise with attenuated intake noise (filter) - BL (free-field sound pressure level Lp, 1m distance, ISO 6798)
** Tier 4 limits attained, with SCR exhaust treatment
*** 42 ppm #2 Diesel, 25 ppm Natural Gas, both with water injection
Questions