Connecticut Department of

ENERGY &
ENVIRONMENTAL
PROTECTION

BUREAU OF AIR MANAGEMENT
NEW SOURCE REVIEW PERMIT
TO CONSTRUCT AND OPERATE A STATIONARY SOURCE

Issued pursuant to Title 22a of the Connecticut General Statutes (CGS) and Section 22a-174-3a of the Regulations of Connecticut State Agencies (RCSA).

Owner/Operator	Yale University
Address	2 Whitney Avenue, 5th Floor, New Haven, CT 06520
Equipment Location	Yale University Central Power Plant, 120 Tower Parkway, New Haven, CT
Equipment Description	Cogeneration Facility Consisting of a 7.9 Megawatt Solar Taurus 70 Gas Turbine and a Victory Heat Recovery Steam Generator with a Coen Grid Style Duct Burner (No. 2)
Town-Permit Numbers	117-0378
Premises Number	48
Stack Number	5
Permit Issue Date	January 13, 2015
Expiration Date	None

/s/Macky McCleary
Macky McCleary
Deputy Commissioner

1/13/2015
Date

This permit specifies necessary terms and conditions for the operation of this equipment to comply with state and federal air quality standards. The Permittee shall at all times comply with the terms and conditions stated herein.

PART I. DESIGN SPECIFICATIONS

A. General Description

Yale University will operate combined heat and power equipment consisting of two Solar Taurus Model 70 combustion turbines, each rated at approximately 7.9 MW and each paired with a supplementary fired HRSG capable of producing approximately 95,000 pounds per hour of 250 psig saturated steam. The new equipment will provide cleaner, more reliable electrical power and steam to Yale's Central/Science Campus.

B. Equipment Design Specifications

1. Turbine
   a. Make and Model: Solar Taurus 70
   b. The maximum rated capacity (Heat input in MMBtu/hr) for the turbines at any ambient temperature (T, in degrees Fahrenheit) should be obtained from the following equations:

Natural Gas:	Heat Input (MMBtu/hr) = $-0.0005T^2 - 0.1859T + 95.555$
ULSD:	Heat Input (MMBtu/hr) = $-0.0004T^2 - 0.1806T + 90.017$

   The above equations for the gas turbines were mathematically derived from the Predicted Engine Performance Data Sheet provided by Solar Turbines (Job ID: 3T311, Aug 7, 2014, Engine Performance Code: Rev. 4.13.1.15.9) and are expected, but not guaranteed values.

2. Duct Burner

   The equipment design specifications for the duct burner represent maximum design values when the turbine and duct burner are operating at 100% load at 20 °F, 60% relative humidity and 1 atm pressure. The values are calculated with the following higher heating values: Natural Gas HHV – 1,000 BTU/scf and ULSD HHV – 138,500 BTU/gal

   a. Make and Model: Victory Energy HRSG with Coen Grid Style Duct Burner
   b. Maximum Natural Gas Firing Rate (scf/hr): 62,000 (when turbine fires natural gas), 64,600 (when turbine fires ULSD)
   c. Maximum Gross Heat Input (MMBTU/hr): 62.0 (when turbine fires natural gas), 64.6 (when turbine fires ULSD)

C. Control Equipment Design Specifications

1. Selective Catalytic Reduction (SCR)
   a. Make and Model: Haldor Topsøe DNX GT-301
   b. Catalyst Type: Porous monolith comprised of titanium dioxide, tungsten trioxide, and divanadium pentoxide along with amorphous silica and vitreous fibers.

2. Oxidation Catalyst
   a. Make and Model: Haldor Topsøe DNX GTC-802
   b. Catalyst Type: Porous monolith comprised of titanium dioxide, tungsten trioxide, and divanadium pentoxide along with amorphous silica and vitreous fibers.

D. Stack Parameters

1. Units Exhausted to this Stack: 2 (Permits 117-0377 and 117-0378)
2. Minimum Stack Height (ft): 149
3. Minimum Exhaust Gas Flow Rate at 100% load (acfm): 138,122
4. Minimum Stack Exit Temperature at 100% load (°F): 244
5. Minimum Distance from Stack to Property Line (ft): 75

   Note: The minimum exhaust gas flow rate and minimum stack exit temperature reflect operation at 20 °F, 60% relative humidity and 1 atm pressure.

PART II. OPERATIONAL CONDITIONS

A. Equipment

1. Turbine
   a. Fuel Types: Natural Gas, ULSD
   b. Maximum Natural Gas Consumption over any Consecutive 12 Month Period for permits 117-0377 and 117-0378 combined (MMCF/yr): 1605
   c. Maximum ULSD over any Consecutive 12 Month Period for permits 117-0377 and 117-0378 combined (gal/yr): 1,255,098
   d. Maximum ULSD Sulfur Content (% by weight, dry basis): 0.0015

2. Duct Burner
   a. Fuel Type: Natural Gas
   b. Maximum Fuel Consumption over any Consecutive 12 Month Period for permits 117-0377 and 117-0378 combined (MMCF/yr): 1209.4

PART III. ALLOWABLE EMISSION LIMITS

The Permittee shall not cause or allow this equipment to exceed the emission limits stated herein at any time.

A. Short Term Emission Limits

These short term emission limits do not apply during periods of startup, shutdown and fuel switching, unless otherwise noted.

1. Criteria Pollutants

a. Turbine Operating on Natural Gas

Pollutant	lb/hr	ppmvd @ 15% O_2	lb/MMBtu
PM (filterable)	1.37	--	0.015(1)
PM_{10} (filterable + condensable)	1.37	--	0.015(1)
$PM_{2.5}$ (filterable + condensable)	1.37	--	0.015(1)
SO_2	0.31	--	--
NOx	0.67	2.0	--
VOC	0.60	--	--
CO	0.41	2.0	--
GHG (as CO_2e)	10,728	--	--

b. Turbine Operating on ULSD

Pollutant	lb/hr	ppmvd @ 15% O_2	lb/MMBtu
PM (filterable)	3.45	--	0.04(1)
PM_{10} (filterable + condensable)	3.45	--	0.04(1)
$PM_{2.5}$ (filterable + condensable)	3.45	--	0.04(1)
SO_2	0.13	--	--
NOx	2.01	6.0	--
VOC	2.84	--	--
CO	1.02	5.0	--
Pb	1.21E-03	--	--
GHG (as CO_2e)	14,108	--	--

c. Turbine Operating on Natural Gas with Duct Burner Operating on Natural Gas

Pollutant	lb/hr	ppmvd @ 15% O_2	lb/MMBtu
PM (filterable)	1.99	--	0.013(1)
PM_{10} (filterable + condensable)	1.99	--	0.013(1)
$PM_{2.5}$ (filterable + condensable)	1.99	--	0.013(1)
SO_2	0.35	--	--
NOx	1.13	2.0	--
VOC	1.84	--	--
CO	0.69	2.0	--
Pb	3.10 E-05	--	--
GHG (as CO_2e)	17,988	--	--

d. Turbine Operating on ULSD with Duct Burner Operating on Natural Gas

Pollutant	lb/hr	ppmvd @ 15% O_2	lb/MMBtu
PM (filterable)	4.10	--	0.03(1)
PM_{10} (filterable + condensable)	4.10	--	0.03(1)
$PM_{2.5}$ (filterable + condensable)	4.10	--	0.03(1)
SO_2	0.17	--	--
NOx	3.44	6.0	--
VOC	4.13	--	--
CO	1.74	5.0	--
Pb	1.24 E-03	--	--
GHG (as CO_2e)	21,672	--	--

(1) This limit shall apply at all times, including periods of startup and shutdown.

2. Non-Criteria Pollutants

For All Operating Scenarios:

Pollutant	lb/hr	ppmvd @ 15% O_2
Ammonia	1.05	5.0

B. Startup, Shutdown and Fuel Switching Emissions

1. The Permittee shall minimize emissions during periods of startup, shutdown and fuel switching by the following work practices and time constraints:
   a. Start the ammonia injection as soon as minimum catalyst temperature is reached;
   b. The oxidation catalyst shall not be bypassed during startup, shutdown or fuel switching;
   c. The duration of startup shall not exceed 60 minutes for a hot start or warm start;
   d. The duration of startup shall not exceed 240 minutes for a cold start;
   e. The duration of shutdown shall not exceed 30 minutes;
   f. The duration of a fuel switch shall not exceed 60 minutes;
   g. A hot start shall be defined as startup when the turbine has been down for less than 8 hours;
   h. A warm start shall be defined as startup when the turbine has been down for 8 or more hours but less than 24 hours;
   i. A cold start shall be defined as startup when the turbine has been down for 24 or more hours;
   j. A fuel switch shall be defined as the period of time beginning with the firing of a fuel other than the initial fuel and ending when the firing of the initial fuel ends and the turbine returns to steady-state operation; and
   k. Emissions during these periods shall be counted towards the annual emission limits stated herein.

2. The NOx CEM shall be operating at all times during periods of startup, shutdown and fuel switching and shall be used to determine NOx emissions during periods of startup, shutdown and fuel switching.

C. Annual Emission Limits

Annual Emission limits below are the limits for permits 117-0377 and 117-0378 combined.

Pollutant	tons per 12 consecutive months
PM (filterable)	19.6
PM_{10} (filterable + condensable)	19.6
$PM_{2.5}$ (filterable + condensable)	19.6
SO_2	3.1
NOx	12.2
VOC	18.4
CO	7.1
Pb	1.5E-03
GHG (as CO_2e)	161,285

D. Hazardous Air Pollutants: This equipment shall not cause an exceedance of the Maximum Allowable Stack Concentration (MASC) for any hazardous air pollutant (HAP) emitted and listed in RCSA Section 22a-174-29. [STATE ONLY REQUIREMENT]

E. Opacity: This equipment shall not exceed 10% opacity during any six minute block average as measured by 40 CFR 60, Appendix A, Reference Method 9.

F. Demonstration of compliance with the above emission limits shall be met by calculating the emission rates using emission factors from the following sources:

Turbine

- NOx: CEM data.
- CO: Control equipment guarantee; stack test.
- VOC: Solar Turbines predicted emission performance data. VOC assumed to be 20% of the unburned hydrocarbon (UHC) value.
- $PM/PM_{10}/PM_{2.5}$: Solar Turbines Product Information Letter (PIL 171, Revision 3), June 1, 2012; stack test.
- SO_2, Pb, HAPs: Ap-42, 5th Edition, Section 3.1, April 2000.
- GHG: 40 CFR Part 98, Table C-1.
- Ammonia: Control equipment guarantee; stack test.
- CO Startup, Shutdown and Fuel Switching Rates:

Fuel	Type of Event	lb/event
Natural Gas	Hot or Warm Start	41.0
	Cold Start	42.6
	Shutdown	22.3
	Fuel Switch to ULSD	36.0
ULSD	Hot or Warm Start	36.0
	Cold Start	37.6
	Shutdown	20.8
	Fuel Switch to Natural Gas	41.0

Duct Burner

- NOx: CEM Data
- CO: Control equipment guarantee; stack test.
- VOC: Victory Energy emissions data.
- $PM/PM_{10}/PM_{2.5}$: Victory Energy emissions data; stack test.
- SO_2, Pb, HAPs: Ap-42, 5th Edition, Section 1.4, July 1998.
- GHG: 40 CFR Part 98, Table C-1

G. The Permittee is not required to demonstrate compliance with the short-term emission limits stated herein during the initial shakedown period. Emissions during the initial shakedown period shall be counted towards the annual emission limits stated herein. The shakedown period shall be defined as the period beginning with initial startup and shall be considered complete upon the conclusion of the initial performance tests.

H. The commissioner may require other means (e.g. stack testing) to demonstrate compliance with the above emission limits, as allowed by state or federal statute, law or regulation.

PART IV. MONITORING, RECORD KEEPING AND REPORTING REQUIREMENTS

A. Monitoring

1. The Permittee shall comply with the CEM requirements as set forth in the DEEP CEMS Guideline and RCSA Section 22a-174-4. CEM shall be required for the following pollutant/operational parameters and enforced on the following basis to demonstrate compliance with the limits in this permit:

Pollutant/Operational Parameter	Averaging Times	Emission Limit	Units
NOx	24 hour rolling	2.0[(1)] (natural gas) 6.0[(1)] (ULSD)	ppmvd @ 15% O2
O_2	1 hour block	--	--

[(1)] Limit does not apply during startup, shutdown or fuel switching.

2. The Permittee shall use individual non-resettable totalizing fuel metering devices or billing meters to continuously monitor natural gas and ULSD fed to this turbine and natural gas fed to this duct burner.

3. The Permittee shall continuously monitor and continuously record the SCR aqueous ammonia injection rate (lb/hr), operating temperature (°F) and pressure drop (inches of water) across the catalyst bed. The Permittee shall maintain these parameters within the ranges recommended by the manufacturer to achieve compliance with the emission limits in this permit.

4. The Permittee shall continuously monitor and continuously record the oxidation catalyst inlet temperature (°F). The Permittee shall maintain this parameter within the range recommended by the manufacturer to achieve compliance with the emission limits in this permit.

5. The Permittee shall perform inspections of the SCR and oxidation catalysts as recommended by the manufacturer.

6. The Permittee shall comply with the monitoring requirements in RCSA Section 22a-174-22, as applicable.

B. Record Keeping

1. The Permittee shall keep records of monthly and consecutive 12 month fuel consumption for this turbine and this duct burner independently. The consecutive 12 month fuel consumption shall be determined by adding (for each fuel) the current month's fuel consumption to that of the previous 11 months. The Permittee shall make these calculations within 30 days of the end of the previous month.

2. The Permittee shall keep records of the fuel certification for each delivery of ULSD from a bulk petroleum provider or a copy of the current contract with the fuel supplier supplying the fuel used by the equipment that includes the applicable sulfur content of the fuel as a condition of each shipment. The shipping receipt or contract shall include the date of delivery, the name of the fuel supplier, type of fuel delivered, the percentage of sulfur in such fuel, by weight, dry basis, and the method used to determine the sulfur content of such fuel.

3. The Permittee shall calculate and record the monthly and consecutive 12 month PM, PM_{10}, $PM_{2.5}$, SO_2, NOx, VOC, CO, Pb, and GHG emissions in units of tons. The consecutive 12 month emissions shall be determined by adding (for each pollutant) the current month's emissions to that of the previous 11 months. Such records shall include a sample calculation for each pollutant. The Permittee shall make these calculations within 30 days of the end of the previous month.

   Emissions during startup, shutdown and fuel switching shall be counted towards the annual emission limitation in Part III.C of this permit.

4. The Permittee shall keep records of the occurrence and duration of any startup, shutdown, fuel switch or malfunction in the operation of the stationary gas turbine/duct burner; any malfunction of the air pollution control equipment; or any periods during which a continuous monitoring system or monitoring device is inoperative.

   Such records shall contain the following information:
   a. type of event (hot, warm or cold startup, shutdown, fuel switch, or malfunction);
   b. equipment affected;
   c. date of event;
   d. duration of event (minutes);
   e. fuel being used during event; and
   f. total NO_x and CO emissions emitted (lb) during the event.

5. The Permittee shall keep records of all exceedances of any operating parameter or emissions limitation. Such records shall include:
   a. the date and time of the exceedance;
   b. a detailed description of the exceedance; and
   c. the duration of the exceedance.

6. The Permittee shall keep records of each delivery of aqueous ammonia. The records shall include:
   a. the date of delivery;
   b. the name of the supplier;
   c. the quantity of aqueous ammonia delivered; and
   d. the percentage of ammonia in solution, by weight.

7. The Permittee shall keep records of the inspection and maintenance of the SCR and oxidation catalysts. The records shall include:
   a. the name of the person;
   b. the date;
   c. the results or actions; and
   d. the date the catalyst is replaced.

8. The Permittee shall keep all records required by RCSA Section 22a-174-22, as applicable.

9. The Permittee shall keep all records required by this permit for a period of no less than five years and shall submit such records to the commissioner upon request.

C. Reporting

1. The Permittee shall notify the commissioner in writing of any exceedance of an operating parameter or emissions limitation, and shall identify the cause or likely cause of such exceedance, all corrective actions and preventive measures taken with respect thereto, and the dates of such actions and measures as follows:
   a. For any hazardous air pollutant, no later than 24 hours after such exceedance commenced; and
   b. For any other regulated air pollutant or operating parameter, no later than ten days after such exceedance commenced.

2. The Permittee shall notify the commissioner in writing of any malfunction of the stationary gas turbine/duct burner, the air pollution control equipment or the continuous monitoring system. The Permittee shall submit such notification within ten days of the malfunction. The notification shall include the following:
   a. a description of the malfunction and a description of the circumstances surrounding the cause or likely cause of such malfunction; and
   b. a description of all corrective actions and preventive measures taken and/or planned with respect to such malfunction and the dates of such actions and measures.

3. The Permittee shall notify the commissioner, in writing, of the date of commencement of construction and the date of initial startup of this equipment. Such written notifications shall be submitted no later than 30 days after the subject event.

4. The Permittee shall comply with all reporting required by RCSA Section 22a-174-22, as applicable.

PART V. STACK EMISSION TEST REQUIREMENTS

A. Initial stack testing shall be required for the following pollutant(s):

☒ PM ☒ PM_{10} ☒ $PM_{2.5}$ ☐ SO_2 ☒ NOx ☒ CO
☐ VOC ☐ Opacity ☒ Other: Ammonia

B. Stack emission testing shall be performed in accordance with the Emission Test Guidelines available on the DEEP website.

C. Stack testing shall be conducted for the following operating modes:
1. turbine only on ULSD;
2. turbine only on natural gas;
3. turbine on ULSD and duct burner on natural gas; and
4. turbine on natural gas and duct burner on natural gas.

D. The gas turbine and duct burner should each be operated at or above 90% of maximum rated capacity for the ambient conditions during the test. The gas turbine maximum rated capacity shall be calculated as specified in Part I.B.1.b of this permit.

E. The Permittee shall conduct initial stack testing within 60 days after achieving the maximum production rate, but not later than 180 days after initial startup. The Permittee shall submit test results within 60 days after completion of testing.

F. Because the Permittee elected to install and certify a NOX-diluent CEMS under 40 CFR §60.4345, then the initial performance test required under 40 CFR §60.8 may be performed in accordance with 40 CFR §60.4405.

G. Recurrent stack testing for CO and ammonia shall be conducted within five years from the date of the previous stack test to demonstrate compliance with their respective limits.

H. Stack test results shall be reported as follows:
1. PM in lbs/MMBtu and lb/hr as filterable only;
2. $PM_{10}/PM_{2.5}$ in units of lb/MMBTU and lb/hr and should include filterable and condensable fractions;
3. NOx and CO in units of ppmvd @ 15% O_2 and lb/hr;
4. Ammonia in units of $\mu g/m^3$, ppmvd @ 15% O_2, and lb/hr.

PART VI. OPERATION AND MAINTENANCE REQUIREMENTS

A. The Permittee shall operate and maintain this equipment in accordance with the manufacturer's specifications and written recommendations.

B. The Permittee shall operate and maintain this equipment, air pollution control equipment, and monitoring equipment in a manner consistent with good air pollution control practices for minimizing emissions at all times including during startup, shutdown, and malfunction.

C. The Permittee shall properly operate the control equipment at all times that this equipment is in operation and emitting air pollutants.

PART VII. SPECIAL REQUIREMENTS

A. The Permittee shall not operate the equipment covered under Permit Nos. 117-0377 and 117-0378 prior to the date of revocation of permit nos. 117-0204, 117-0205, and 117-0206.

B. The Permittee shall comply with all applicable sections of the following New Source Performance Standard at all times.

Title 40 CFR Part 60, Subparts KKKK and A.

Copies of the Code of Federal Regulations (CFR) are available online at the U.S. Government Printing Office website.

C. In the event that a malfunction causing either an emission exceedance or a parameter monitored out of recommended range is not corrected within three hours, the Permittee shall immediately institute shutdown of the turbine/duct burner.

D. The Permittee shall operate this facility at all times in a manner so as not to violate or contribute significantly to the violation of any applicable state noise control regulations, as set forth in RCSA Sections 22a-69-1 through 22a-69-7.4. [STATE ONLY REQUIREMENT]

PART VIII. ADDITIONAL TERMS AND CONDITIONS

A. This permit does not relieve the Permittee of the responsibility to conduct, maintain and operate the regulated activity in compliance with all applicable requirements of any federal, municipal or other state agency. Nothing in this permit shall relieve the Permittee of other obligations under applicable federal, state and local law.

B. Any representative of the DEEP may enter the Permittee's site in accordance with constitutional limitations at all reasonable times without prior notice, for the purposes of inspecting, monitoring and enforcing the terms and conditions of this permit and applicable state law.

C. This permit may be revoked, suspended, modified or transferred in accordance with applicable law.

D. This permit is subject to and in no way derogates from any present or future property rights or other rights or powers of the State of Connecticut and conveys no property rights in real estate or material, nor any exclusive privileges, and is further subject to any and all public and private rights and to any federal, state or local laws or regulations pertinent to the facility or regulated activity affected thereby. This permit shall neither create nor affect any rights of persons or municipalities who are not parties to this permit.

E. Any document, including any notice, which is required to be submitted to the commissioner under this permit shall be signed by a duly authorized representative of the Permittee and by the person who is responsible for actually preparing such document, each of whom shall certify in writing as follows: "I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify that based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that any false statement made in the submitted information may be punishable as a criminal offense under section 22a-175 of the Connecticut General Statutes, under section 53a-157b of the Connecticut General Statutes, and in accordance with any applicable statute."

F. Nothing in this permit shall affect the commissioner's authority to institute any proceeding or take any other action to prevent or abate violations of law, prevent or abate pollution, recover costs and natural resource damages, and to impose penalties for violations of law, including but not limited to violations of this or any other permit issued to the Permittee by the commissioner.

G. Within 15 days of the date the Permittee becomes aware of a change in any information submitted to the commissioner under this permit, or that any such information was inaccurate or misleading or that any relevant information was omitted, the Permittee shall submit the correct or omitted information to the commissioner.

H. The date of submission to the commissioner of any document required by this permit shall be the date such document is received by the commissioner. The date of any notice by the commissioner under this permit, including but not limited to notice of approval or disapproval of any document or other action, shall be the date such notice is personally delivered or the date three days after it is mailed by the commissioner, whichever is earlier. Except as otherwise specified in this permit, the word "day" means calendar day. Any document or action which is required by this permit to be submitted or performed by a date which falls on a Saturday, Sunday or legal holiday shall be submitted or performed by the next business day thereafter.

I. Any document required to be submitted to the commissioner under this permit shall, unless otherwise specified in writing by the commissioner, be directed to: Office of Director; Engineering & Enforcement Division; Bureau of Air Management; Department of Energy and Environmental Protection; 79 Elm Street, 5th Floor; Hartford, Connecticut 06106-5127.