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U.S. Department  
of Transportation

East Building, PHH – 30  
1200 New Jersey Avenue, Southeast  
Washington, D.C. 20590

**Pipeline and Hazardous  
Materials Safety Administration**

DOT-SP 16560

EXPIRATION DATE: April 30, 2018

(FOR RENEWAL, SEE 49 CFR § 107.109)

1. GRANTEE: LightSail Energy, Inc.  
Berkeley, CA
2. PURPOSE AND LIMITATIONS:
  - a. This special permit authorizes the manufacture, mark, sale and use of a non-DOT specification fully wrapped carbon fiber reinforced composite cylinder with a non-load sharing plastic liner for the purpose of transporting certain non-liquefied compressed gases in commerce. This cylinder meets all of the requirements of the ISO 11515 Standard with the exception of the design water capacity and the design safety factor. This special permit provides no relief from the Hazardous Materials Regulations (HMR) other than as specifically stated herein. The most recent revision supersedes all previous revisions.
  - b. The safety analyses performed in development of this special permit only considered the hazards and risks associated with transportation in commerce. The safety analyses did not consider the hazards and risks associated with consumer use, use as a component of a transport vehicle or other device, or other uses not associated with transportation in commerce.
  - c. Party status will not be granted to this special permit.
3. REGULATORY SYSTEM AFFECTED: 49 CFR Parts 106, 107 and 171-180.

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4. REGULATIONS FROM WHICH EXEMPTED: 49 CFR § 173.302(a) in that non-DOT specification cylinders are not authorized, except as specified herein.
5. BASIS: This special permit is based on the application of LightSail Energy, Inc. dated August 20, 2015, submitted in accordance with § 107.105 and the public proceeding thereon and additional information, dated December 15, 2015.
6. HAZARDOUS MATERIALS (49 CFR § 172.101):

<b>Hazardous Material Description</b>			
<b>Proper Shipping Name</b>	<b>Hazard Class/ Division</b>	<b>Identification Number</b>	<b>Packing Group</b>
Argon, compressed	2.2	UN1006	N/A
Helium, compressed	2.2	UN1046	N/A
Hydrogen, compressed	2.1	UN1049	N/A
Methane, compressed or Natural gas, compressed ( <i>with high methane content</i> )	2.1	UN1971	N/A
Neon, compressed	2.2	UN1065	N/A
Nitrogen, compressed	2.2	UN1066	N/A

**Note:** See paragraph 7.d for cylinder service limitations.

7. SAFETY CONTROL MEASURES:

a. PACKAGING - Packaging prescribed is a non-DOT specification fully wrapped fiber reinforced composite cylinder with a non-load sharing plastic liner as described in LightSail Energy, Inc.'s application on file with the Office of Hazardous Materials Safety Approvals and Permits Division (OHMSAPD) and which is shown on LightSail Energy drawings #11289-1,2 and 3. Each cylinder must meet all the design and construction requirements for UN composite cylinders specified in § 178.71(1) and ISO Standard 11515 (Gas Cylinders - Refillable composite reinforced tubes of water capacity between 450L and 3,000L - Design, construction and testing) except as follows:

(1) **§ 1 Scope** - Cylinders made under this special permit are limited to a minimum water volume of 450 Liters and a maximum water volume of 8500 Liters, a maximum working pressure up to 250 bar (3625 psi), a maximum diameter of 42 inches and a maximum length of 38 feet.

(2) **§ 8.1 Type approval procedure, General requirements** -

(i) A DOT Independent Inspection Agency (IIA), approved in writing by the Associate Administrator for Hazardous Materials Safety (AAHMS) must, in accordance with 49 CFR Part 107, Subpart I, review the results of the design qualification testing that was submitted in the application for special permit. The IIA must either verify that the cylinder design meets the requirements of the special permit based on the test results and other documentation submitted in the application for special permit, or the IIA may require additional testing and/or information from the manufacturer in order to verify the cylinder design meets all requirements of the special permit. Prior to cylinder production, the IIA's verification of the cylinder design must be submitted to and acknowledged in writing by the OHMSAPD.

(ii) Prior to any manufacture of cylinders under this special permit, an IIA, approved in writing by the AAHMS, must provide inspections and verifications of all batch testing and all new design qualification testing in accordance with the requirements of this special permit.

(3) **§ 8.2 Prototype tests** - Cylinders that are manufactured for prototype testing must be representative of production units.

(i) A representative (subscale) prototype cylinder is shorter in length than the production unit, but has the same nominal diameter. It is manufactured using the same materials and

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manufacturing technique, and has a composite wrapping pattern (same number of strands and layers) that represents an equivalent stress condition when compared to a full scale prototype.

(ii) The design submission will cover a design family of composite cylinders of the same diameter and pressure with different cylindrical lengths from 2 times the diameter and up to 3.8 times the length of the representative composite cylinder and with a water capacity between 450 Liters and 8,500 Liters.

(iii) § 8.2.2, § 8.2.3, § 8.2.4 - The IIA must witness all testing as specified in this special permit (see Table 2).

(4) **§ 8.4 Design Variants** - Table 2 shown below (Qualification for Design Variants) may be used in lieu of Table 4 presented in ISO 11515:

Table 2. Qualification tests for cylinder design variants.

Qualification for Design Variants														
	New Design	Length ≤50%	Length >50%	Diameter ≤20%	Diameter >20% or ≤50%	Liner thickness >20%	Liner material	Equivalent fiber	Test pressure ≤20%	Test pressure >20% or ≤60%	Composite thickness or pattern	Boss-to-liner interface	Equivalent resin matrix	Resin Matrix
Liner Material							X							
Composite material								X			X <sup>1</sup>		X <sup>1</sup>	
Hydraulic pressure	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tube burst	X	X <sup>1</sup>	X <sup>1</sup>	X <sup>1</sup>	X	X <sup>1</sup>	X <sup>1</sup>	X	X <sup>1</sup>	X	X	X <sup>1</sup>	X <sup>1</sup>	X <sup>1</sup>
Ambient cycle	X			X <sup>1</sup>	X		X	X <sup>1</sup>	X <sup>1</sup>	X	X	X <sup>1</sup>		
Environmental cycle	X													X
Flaw	X				X <sup>1</sup>									X <sup>1</sup>
Blunt impact	X				X <sup>2</sup>					X <sup>1</sup>				X

High velocity impact (gunfire)	X				X <sup>2</sup>					X				X
Neck strength	X						X					X		X
Leak	X			X			X		X	X		X		
Permeability	X				X	X	X			X <sup>1</sup>				
Gas cycling	X				X <sup>1</sup>	X <sup>1</sup>	X					X <sup>1</sup>		

**Notes:**

1. For a new cylinder design with a water volume larger than 450 L, a minimum of 1 cylinder may be used for each design change. For a design change to the boss-liner interface, a leak check of the liner interface is acceptable. The pneumatic cycle test is not required if the boss-liner interface does not change.

(5) **§ 8.5 Type approval test procedures and criteria -**

(i) § 8.5.1.1 Hydraulic proof pressure test, Procedure - The test pressure shall be held for at least 30 seconds with the tube isolated from the pressure source, during which time there shall be no decrease in the recorded pressure or evidence of any leakage.

(ii) § 8.5.4.2 Tube burst test criteria, Criteria - The burst pressure,  $p_b$ , or pressure at failure shall not be less than 1.6 times the test pressure,  $P_h$ , of the composite cylinder.

(iii) § 8.5.5 Ambient cycle test - The cylinders must be cycled to an upper pressure value of at least 1.3 times the working pressure.

(iv) § 8.5.6.2 Environmental cycle test, Procedure - The cylinder shall be conditioned at a maximum internal pressure of 10% of the working pressure. The minimum pressure during cycling shall not be greater than 10% of the working pressure.

(v) § 8.5.6.3 Environmental cycle test, Criteria - The burst pressure,  $p_b$ , must be not less than 1.4 times the test pressure,  $p_h$ .

(vi) § 8.5.11 Leak test - An acceptable procedure for leak testing is to pressurize the cylinder to the working pressure using a suitable fluid. With

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the cylinder having been pressurized for at least 15 minutes, carefully examine for signs of leakage (e.g., a visual indication or decrease in pressure).

(vii) § 8.5.12 Accelerated stress rupture test - The accelerated stress rupture test is not required for cylinders reinforced with carbon fiber.

(viii) § 8.5.14.2 Gas cycle test, Procedure - One finished cylinder shall be cycle tested according to the following procedure:

- Fill the cylinder to be tested with a non-corrosive fluid such as oil, inhibited water or glycol;
- Cycle the pressure in the cylinder for 1,000 cycles, between 10% of working pressure and working pressure. The pressure cycling rate shall not exceed 10 cycles per minute;
- Release the pressure, drain the fluid, and dry the interior of the cylinder;
- Cycle the pressure in the cylinder for 5 cycles, between 10% of working pressure and working pressure, with air, nitrogen or other gas determined by the inspector. The pressure cycling rate must provide at least a 2 hour hold at the high pressure portion of the cycle;
- Following the high pressure hold of the final cycle, the gas shall be released freely to atmosphere; and
- The cylinder must then be subjected to a leak test. Following the completion of the test liner and liner/end boss interface must undergo a visual inspection for evidence of any deterioration, such as fatigue cracking or electrostatic discharge.

(ix) § 8.5.14.3 Gas cycle test, Criteria - The cylinder must have no signs of leakage or deterioration.

(x) § 8.5.15 Coatings test - This test is not required for uncoated cylinders.

(xi) § 8.5.16 Salt spray test - This test is not required for plastic lined cylinders.

(xii) § 8.5.17 Acid environmental test - This test is not required for carbon fiber reinforced cylinders.

(xiii) § 8.5.18 Vacuum test - This test is not required if a warning is placed on the cylinder to indicate that use under vacuum conditions is not permitted.

(6) **§ Batch inspection and testing.**

(i) § 9.2.4 Liner batch inspection & testing, Criteria - The supplier's certification of the liner and liner boss properties may serve as verification of compliance with the design specifications.

(ii) § 9.4 Overwrap materials - The supplier's certification of the fiber and resin matrix properties may serve as verification of compliance with the ISO 11515 Standard.

(iii) § 9.5.6 Composite tube, Batch inspection - A batch test shall be conducted on one cylinder out of 5 batches or one year of cylinder production, whichever comes first. A batch here is defined by the production quantity of up to 200 finished cylinders successively produced (plus finished cylinders required for destructive testing), of the same nominal diameter, thickness and design. The batch of finished cylinders may contain different batches of liners, fibers and matrix materials.

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(iv) § 9.5.7 Batch testing criteria - The burst test may be conducted on the first unit of the batch. After reaching the minimum required burst pressure, and holding for 5 seconds, the cylinder shall have passed the test.

(7) **§ Cylinder marking** - The marking must contain the following:

(i) The DOT special permit number followed by working pressure expressed in bar (psig). The marking may be on a label permanently attached to the outside of the cylinder.

(ii) A serial number and the manufacturer's identification number or a symbol as obtained from the Associate Administrator for Hazardous Materials Safety, located just below or immediately following the DOT marking. The serial number and the manufacturer's identification number may be placed on the boss provided the markings are accessible for inspection.

(iii) The DOT IIA official mark must be placed near the serial number. The marking must contain date the (month and year) of the initial hydraulic proof pressure test for that cylinder.

(iv) The size of the letters and numbers used must be at least 0.64 cm (1/4 inch) high if space permits.

(v) The following are examples of an authorized format for marking:

DOT-SP AAAAA-YYYY

(Where AAAAA is the special permit number and YYYY is the working pressure)

CCCC MMI

(Where CCCC is the serial number and MMI is the manufacturer's mark or symbol)

DDD - MM/YY

(Where DDD is the inspector's mark and MM/YY is the month and year of the hydraulic proof pressure test).

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Additional markings are permitted, provided the additional markings do not obscure the required marking and are not detrimental to the integrity of the cylinder. Provisions for marking of the required requalification dates and RIN information must be made near the cylinder markings.

b. ADDITIONAL REQUIREMENTS FOR EACH NEW DESIGN

(1) **Fire Protection System** - Each tube assembly must be equipped with a Fire Protection System (FPS) as described in the LightSail Energy, Inc. application on file with the OHMSAPD. The FPS has the following characteristics:

(i) The FPS consists of a shape memory alloy wire linkage that is encapsulated in stainless steel tubing. During a fire scenario, the linkage acts as a trigger for the tank assembly's Pressure Relief Device (PRD) and, through mechanical action, activates the PRD to vent the hazardous lading from the system.

(ii) The FPS vent lines direct the released gas upwards and outside of the frame system.

(iii) No additional pressure relief devices (e.g., rupture disks) are authorized on the tubes.

(2) **High Velocity Impact Test** - The cylinders shall be tested in accordance with the ISO Standard 11119-3 (Gas Cylinders - Refillable composite gas cylinders and tubes - Part 3: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450L with non-load sharing metallic or non-metallic liners) with the exception that the cylinder shall be impacted by a 12.7 millimeter (0.5 caliber) armor-piercing projectile. If a single projectile will not penetrate the wall, additional rounds may be used.

c. REQUALIFICATION -

(1) Each cylinder must be requalified once every 5 years by a qualified person holding a valid DOT RIN in accordance with § 107.805 as follows:

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(i) Perform an external and internal visual inspection in accordance with CGA pamphlet C-6.2 (Guidelines for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders) and a hydraulic proof pressure test at a pressure equal to 1.5 times the marked working pressure. The pressure shall be held for a minimum of 3 minutes without loss of pressure.

(ii) Perform a Non-destructive Examination (NDE) which is approved by the OHMSAPD and which may be used in lieu of internal visual inspection and hydraulic proof pressure test.

(2) Persons who perform inspection and testing of cylinders subject to this special permit must comply with § 180.205(b) and with all the terms and conditions of this special permit and the HMR.

(3) Requalification date (month/year) must be permanently marked on the cylinder as specified in paragraph § 180.213. The marking of the RIN symbol on the cylinder certifies compliance with all of the terms and conditions of this special permit.

d. OPERATIONAL CONTROLS -

(1) Cylinders manufactured under this special permit are not authorized for use 15 years from the date of manufacture, except as specified under paragraph 8.a. of this special permit.

(2) A cylinder that has been subjected to fire may not be returned to service.

(3) Cylinders are permanently mounted inside of framing that is designed, marked (approval plate) and approved in accordance with the International Convention for Safe Containers (CSC) (49 CFR Part 451) as described in the LightSail Energy, Inc. application on file with the OHMSAPD. The structural framework has been evaluated for transportation of the tubes under this special permit by Finite Element Analysis (FEA) on file with the OHMSAPD. This FEA has demonstrated the framework's ability to protect the tubes from damage

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due to front, rear, or side impact, and rollover.

The frame design meets the following:

(i) All requirements of § 173.301(i);

(ii) All requirements of CGA TB-25; and

(iii) The LightSail Energy, Inc. gas transport module shall be transported on trailers that are pulled by tractors equipped with an Electronic Stability Control (ESC) System in accordance with the Federal Motor Vehicle Safety Standard (FMVSS) 136. When an ESC equipped tractor is not used, the trailer shall be equipped, in accordance FMVSS 393.55, with an Anti-Lock Braking (ABS) System that contains an electrical circuit to signal a malfunction in the trailer's ABS system.

(4) Cylinder (tube) handling - The cylinder must be rejected if, during the manufacturing and/or prior to being mounted to the CSC framing, it drops from a height greater than 2 feet.

(5) Fire protection System (FPS) Inspection - Prior to each filling, the FPS and PRV must be inspected in accordance with the LightSail Energy Inspection Procedure, on file with the OHMSAPD.

(6) Cabinet Flammability Limit - The Lower Flammability Limit (LEL) of each gas or gas mixtures must be calculated for the highest pressure and temperature to ensure the cabinet of the cylinder assembly is equipped with proper ventilation to avoid a fire or explosion during transportation.

(7) Prior to use in Offshore Service under the terms of this special permit, additional information justifying such use must be submitted to and acknowledged in writing by the AAHMS.

(8) Low pressure/temperature prior to filling - The following procedure must be followed in case the pressure of a cylinder (tube) drops below 100 psig (7 bar) while the ambient temperature is below -12°C: Prior to filling, either the tube must be held at or

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above 16°C for 8 hours, or the tube must be filled to 435 psig (30 +/- 3 bar) from a compressor, and held for one hour, before returning to normal fill procedures.

(9) Transportation of Division 2.1 (flammable gas) is not authorized aboard cargo vessel unless specifically authorized in the Hazardous Materials Table (§ 172.101).

(10) When transported by cargo vessel, the cylinders must be stowed on deck only and are prohibited from passenger ships (Stowage Category D).

(11) Standard Operating Procedures (SOP) that govern the inspection of the Fire Protection System (FPS), gauges, fittings, valves and vent system will be submitted to the OHMSAPD before the deployment of the first production unit. SOPs that govern filling/discharging operations and incident reporting will also be provided in advance of the first unit's deployment.

8. SPECIAL PROVISIONS:

a. Cylinders manufactured under this special permit are authorized for a maximum service life of 15 years from the date of manufacture unless approved by the OHMSAPD for an additional 15 years under a pre-approved service life extension program that must be submitted within 12 months of the date on which the special permit is granted.

b. In accordance with the provisions of Paragraph (b) of § 173.22a, persons may use the packaging authorized by this special permit for the transportation of the hazardous materials specified in paragraph 6, only in conformance with the terms of this special permit.

c. A person who is not a holder of this special permit, but receives a package covered by this special permit, may reoffer it for transportation provided no modification or change is made to the package and it is offered for transportation in conformance with this special permit and the HMR.

d. A current copy of this special permit must be maintained at each facility where the package is offered or reoffered for transportation.

- e. Each packaging manufactured under the authority of this special permit must be either (1) marked with the name of the manufacturer and location (city and state) of the facility at which it is manufactured or (2) marked with a registration symbol designated by the Office of Hazardous Materials Special Permits and Approvals for a specific manufacturing facility.
- f. A current copy of this special permit must be maintained at each facility where the packaging is manufactured under this special permit. It must be made available to a DOT representative upon request.
9. MODES OF TRANSPORTATION AUTHORIZED: Motor vehicle, rail freight and cargo vessel.
10. MODAL REQUIREMENTS: A current copy of this special permit must be carried aboard each cargo vessel or motor vehicle used to transport packages covered by this special permit.
11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this special permit and penalties prescribed by the Federal hazardous materials transportation law, 49 U.S.C. 5101 et seq:
- o All terms and conditions prescribed in this special permit and the Hazardous Materials Regulations, 49 CFR Parts 171-180.
  - o Persons operating under the terms of this special permit must comply with the security plan requirement in Subpart I of Part 172 of the HMR, when applicable.
  - o Registration required by § 107.601 et seq., when applicable.

Each "Hazmat employee", as defined in § 171.8, who performs a function subject to this special permit must receive training on the requirements and conditions of this special permit in addition to the training required by §§ 172.700 through 172.704.

No person may use or apply this special permit, including display of its number, when this special permit has expired or is otherwise no longer in effect.

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Under Title VII of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)–“The Hazardous Materials Safety and Security Reauthorization Act of 2005” (Pub. L. 109-59), 119 Stat. 1144 (August 10, 2005), amended the Federal hazardous materials transportation law by changing the term “exemption” to “special permit” and authorizes a special permit to be granted up to two years for new special permits and up to four years for renewals.

12. REPORTING REQUIREMENTS: Shipments or operations conducted under this special permit are subject to the Hazardous Materials Incident Reporting requirements specified in 49 CFR §§ 171.15 - Immediate notice of certain hazardous materials incidents, and 171.16 - Detailed hazardous materials incident reports. In addition, the grantee(s) of this special permit must notify the Associate Administrator for Hazardous Materials Safety, in writing, of any incident involving a package, shipment or operation conducted under terms of this special permit.

Issued in Washington, D.C.:



for Dr. Magdy El-Sibaie  
Associate Administrator for Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Pipeline and Hazardous Material Safety Administration, U.S. Department of Transportation, East Building PHH-30, 1200 New Jersey Avenue, Southeast, Washington, D.C. 20590.

Copies of this special permit may be obtained by accessing the Hazardous Materials Safety Homepage at [http://hazmat.dot.gov/sp\\_app/special\\_permits/spec\\_perm\\_index.htm](http://hazmat.dot.gov/sp_app/special_permits/spec_perm_index.htm) Photo reproductions and legible reductions of this special permit are permitted. Any alteration of this special permit is prohibited.

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