Summary Specification
HIGHLY FLEXIBLE CARBON FIBER SEMI-PRODUCTION LINE
May 3, 2010, Rev. 0

1. This specification defines the requirements for a highly flexible Carbon Fiber Semi-production Line (CFSL). It is intended to be capable of producing various carbon fiber grades including standard modulus commercial grades, intermediate modulus aerospace grades, and fiber grades that are currently in development at both ends of the cost and performance spectrum.
2. The CFSL shall be highly instrumented and capable of processing any of several kinds of precursor fibers including those based on PAN, pitches, lignin, polyethylene, and rayon in tow, nonwoven mat, or discontinuous, loose fiber form. It shall accommodate polyacrylonitrile (PAN) tow sizes from 3k to 80k at 1.25 denier per filament (dpf). The line shall be rated at >= 25,000 kg of annual production, based on 24k PAN tows with 1.25 dpf and 6,000 annual operating hours. The Seller shall deliver a fully integrated line, including all ovens and furnaces; pre- and post-treatment modules; conveyance and packaging equipment; tensioning and drawing equipment; effluent treatment equipment; and data acquisition and control hardware and software. Data acquisition and control shall be centralized in a dedicated control center. The CFSL shall be installed in a new building that is currently in design. The Seller shall include equipment installation in its proposal, as an option that may be selected or declined by the Company.
3. The CFSL shall satisfy the following system requirements:
    1. >= 25,000 kg annual production capacity, based on 24k PAN tows with 1.25 dpf
    2. Maximum line speed >= 1.5 m/min
    3. Line width >= 300 mm
    4. Tow size from 3k – 80k at 1.25 dpf
    5. Tow band >= 24 tows for 24k or smaller tows, reduced tow count allowable for tow size > 24k
    6. Availability >= 6,000 hrs/yr
    7. The CFSL shall be designed to handle the worst case loads (e.g., gas evolution rate) from PAN, pitch, or rayon fibers. It shall additionally be designed for loads from lignin or polyethylene based on effluent estimates that shall be provided by the Company.
    8. The CFSL shall operate as a fully integrated system with central computer control and data acquisition.
    9. The data acquisition and control system shall prevent unauthorized access to restricted information.
4. The general CFSL configuration is illustrated in Figure 1 and Figure 2 and shall include the following equipment modules:
    1. Spooled precursor creel with fixed spindles for the number of 24k tows, and four spare spindles mounted on a portable platform
    2. Baled precursor feed station on a mezzanine
    3. Bulk material feed station
    4. Pre-treatment system
    5. Drive unit
    6. Tow oxidation ovens with six thermal zones; driven passback rolls at the front end of all thermal zones; drive units after each of the first three thermal zones; one thermal zone compatible with sulfurous effluent; all zones rated to 400 ºC; designed with features to facilitate the investigation of variations in critical processing parameters such air flow, velocity, and temperature
    7. Drive unit after tow oxidation ovens

8. Parallel to the tow oxidation ovens shall be a bulk materials oxidation oven, with six thermal zones and belt conveyor.
9. Low-temperature (LT) carbonization furnace, rated to 1,000 ºC, able to carbonize both tows and bulk materials; configured to enable carbonization at the entrant end, followed by oxidation in steam or CO_2 at the exit end.
10. Drive unit
11. High-temperature (HT) carbonization furnace rated to 2,000 ºC, able to carbonize both tows and bulk materials
12. Drive unit
13. Surface treatment unit including washing and drying
14. Drive unit
15. Tow band spreading unit
16. Size application unit including drying
17. Drive unit
18. Take-up winding station, with fixed spindles for the number of 24k tows, plus four spare spindles mounted on a portable platform
19. Bulk packaging station on a mezzanine

In addition to the above in-line equipment, other essential equipment includes a regenerative thermal oxidizer, thermal oxidizer, effluent emission stacks, and control and data acquisition system. All equipment and software shall be fully integrated and optimized to function as a single system with single-point operational control.

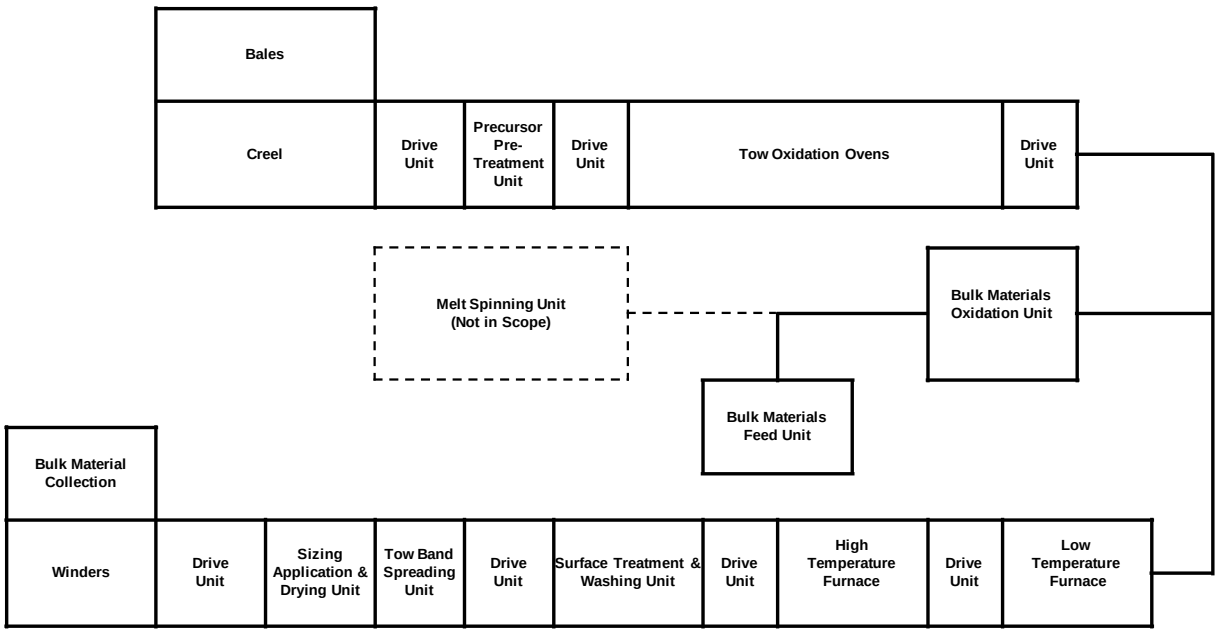

Figure 1. General CFSL equipment configuration.

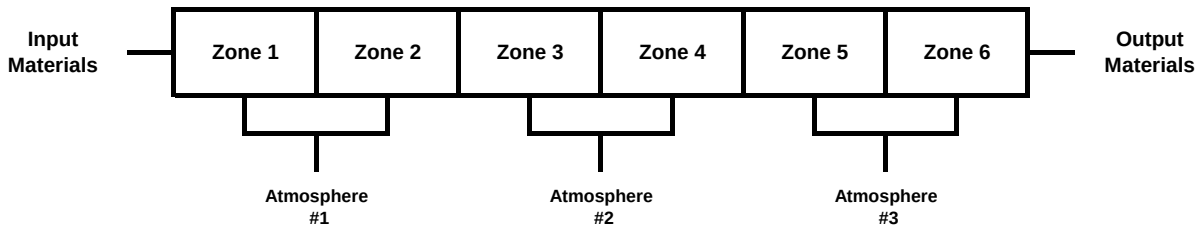

Figure 2. Bulk material oxidizer configuration.

5. The CFSL shall be upgradeable by the future addition of the following equipment and/or features:
    1. Creel or similar equipment to temporarily store spools of fiber (on heat-resistant cores) in the bulk materials feed area, and to load them onto the bulk oxidizer conveyor .
    2. Creel to transfer oxidized (stabilized) fiber from spools of fiber exiting the bulk oxidizer to the LT furnace
    3. Ultra-high temperature furnace rated >= 2,800ºC
    4. Advanced surface treatment unit
    5. Additional sizing unit
    6. Scrubbers for treating sulfurous off-gases

    The equipment structures shall be designed to provide structural support for this equipment so that it can be added in the future with little or no structural modification.