A ‘Highly’ Flexible Carbon Fiber Research Facility

Intertech PIRA GOCarbonFiber 2011

October 5, 2011

Agenda

- Introduction of Harper International
  - Background
  - Relationship to Oak Ridge National Laboratory (ORNL)
    - Carbon Fiber Technology Facility (CFTF) Project
- ORNL – CFTF Project
  - Technical Features
  - Equipment
    - Overview – General Arrangement and Layout
    - Advanced Oxidation Oven Technology
    - Pre-Carbonization & Carbonization
  - Material Feed Types
    - Tow and Bulk Material Handling
    - Traditional and Next Generation Pre-Cursors
  - ORNL Carbon Fiber Consortium

Harper International Background & Core Competencies

Harper Technical Profile – Core Skills

Scale up of New or Challenging Processes

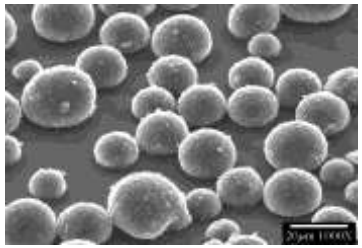
- 300°C to 3000°C
- Atmospherically Controlled
- Continuous Processing

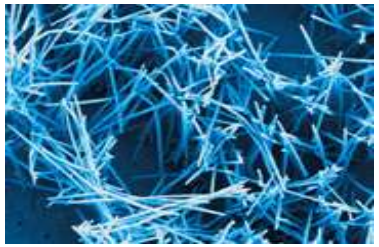
Construction Techniques in

- Metallic > Ceramic > Graphitic
- Integrated Systems Design – Plant Supply
- Complex Flows of Advanced Materials
- Precise Control of Gas - Solids Interactions

Broad Experience Base in a Range of Carbon Processes

- PAN based C-fiber
- Pitch based C-fiber
- Rayon based C-fiber
- Alternative Precursor Development
- Carbon Fiber Recycling





Harper International
Typical Services to Carbon Fiber Industries

- Equipment Supply (~40 Years)
  - LT, HT and UHT Furnaces
  - Oxidation Ovens
  - Surface Treatment & Drying
  - Mass Transport
- Complete System Supply (~15 Years)
- Research and Development
- Retrofits, Revamps & Upgrades
- Business Development: Feasibility Studies & Modeling
- Training & Optimizations

Harper International
CF Line Full Line Scope of Supply

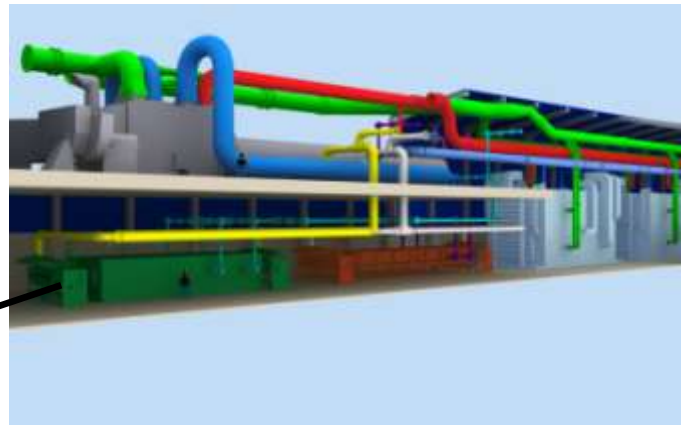
Proven Supplier of Complete Carbon Fiber Systems

with

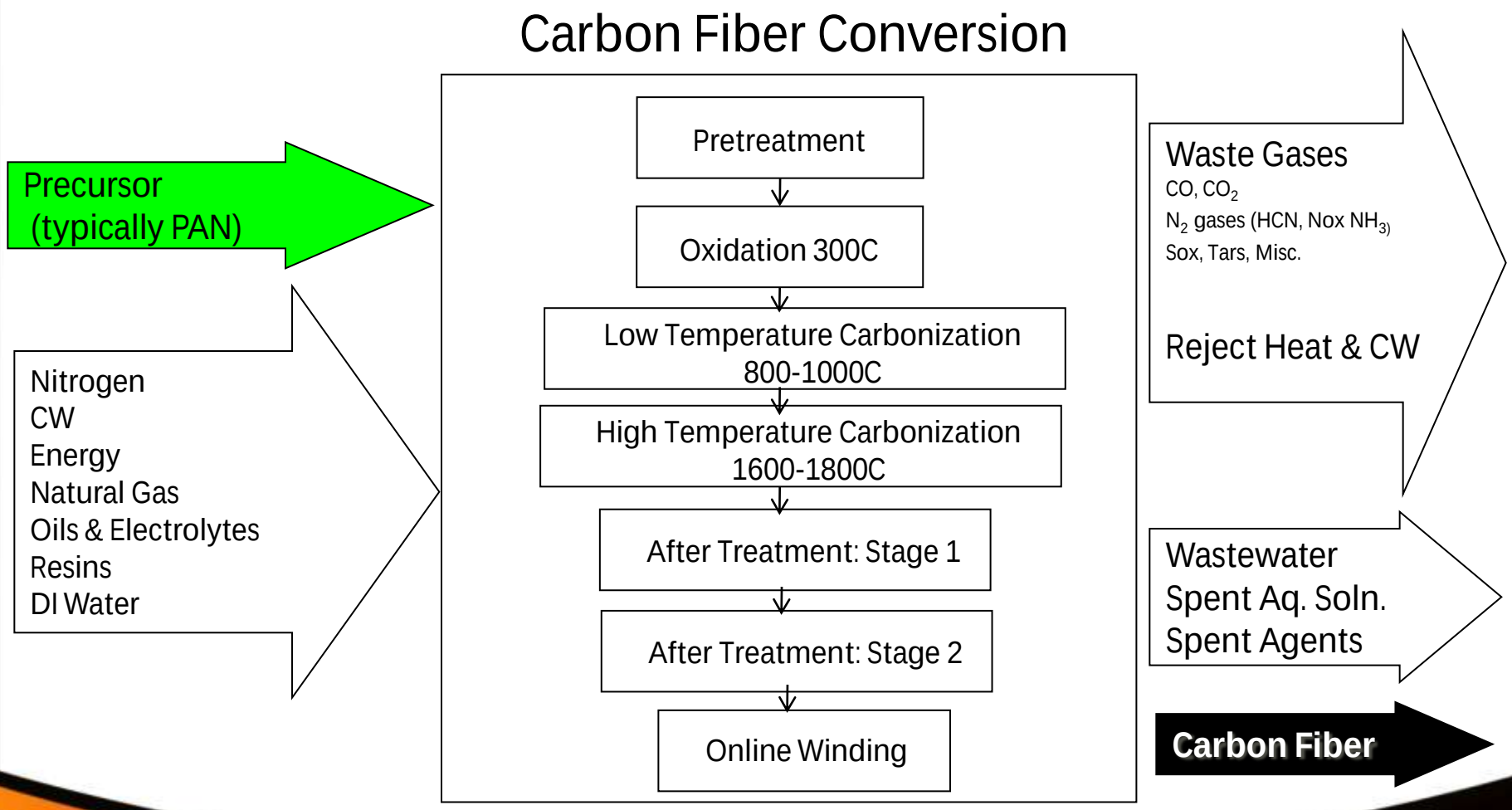
Multiple References

Carbon Fiber Systems
Scale of Operations

Scale	Size Range (mm Width)	Capacity
Production	1000mm - 4200mm	100tpy to More Than 2000 tpy
Industrial Scale Pilot	300mm - 1000mm	20tpy - 100 tpy
Micro Scale (University, Institute)	<100mm	Less Than 1 tpy



Carbon Fiber Conversion Process



Oak Ridge National Laboratory
Carbon Fiber Technology Facility

Unique Features & Functions

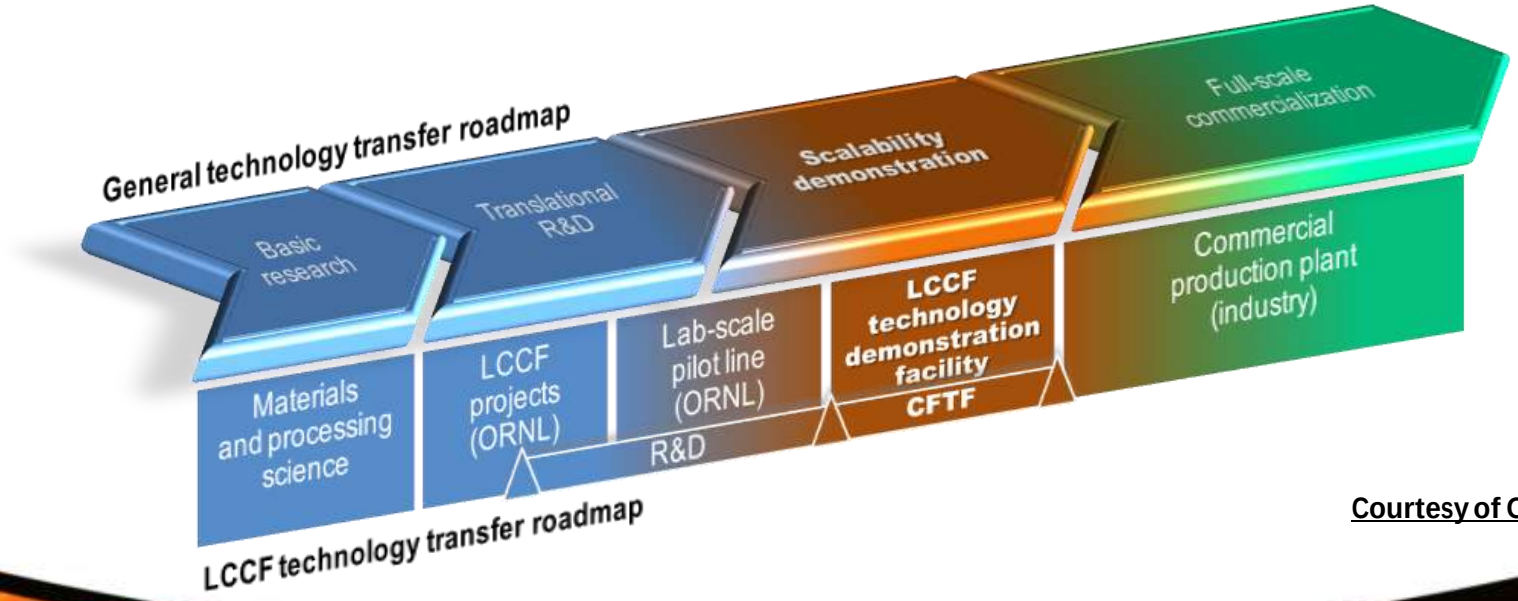
Oak Ridge National Laboratory (ORNL)
Carbon Fiber Technology Facility

Bridges Gap Between R&D and Commercialization

Existing research focus

- Alternative precursors
- Advanced conversion processes

CFTF will scale the R&D results to semi-production scale.



Courtesy of ORNL

ORNL Carbon Fiber Technology Facility

Background and History

- Project Launch (Request for Tenders) July 2010
  - Establish Industrial Scale Pilot Plant based on 'Convention ' Processing
  - Prepare 'Next Generation' Advanced Conversion Technologies
- System Description:

  http://www.ornl.gov/adm/contracts/CFSL%20Spec%20Final%20R0.pdf

- System Available for Use in First Quarter 2013
- Collaborative Based Research Facility
- Primary Contact:

  CFTF@ORNL.GOV

ORNL Carbon Fiber Technology Facility

Key Features

- Highly instrumented, highly flexible conventional carbon fiber line for "any precursor in any format"
- Melt-spun fiber line to produce precursor fibers
- Provisions for additional future equipment
- Produce up to 25 tons/year of carbon fibers
- Demonstrate technology scalability
- Train and educate workers
- Grow partnerships with US industry
- Demonstrate LCCF technology scalability
- Produce quantities of Low-Cost Carbon Fiber needed for evaluations & prototyping

Notional facility and equipment perspective

Courtesy of ORNL

ORNL Carbon Fiber Technology Facility

Features and Functions

- Flexible Carbon Fiber Conversion Line
  - Rating for 25 TPY of PAN Conversion
  - Capable of Processing Alternative Materials (Pitch, PAN, Lignin)
- Ability to Handle Bulk Materials
  - Belts in all Thermal Process Units (Ovens, LT, HT)
  - Enables Processing a Range of Alternative Precursors
- Upstream In-Line Melt Spinner (by Others)
  - Continuous Melt Spin Processing Without Re-Spooling
- Atmospheric Control in All Thermal Process Units
  - Enables Processing a Range of Alternative Precursors
- Instrumented for Research with an Integrated Control System and Data Collection

ORNL Carbon Fiber Technology Facility

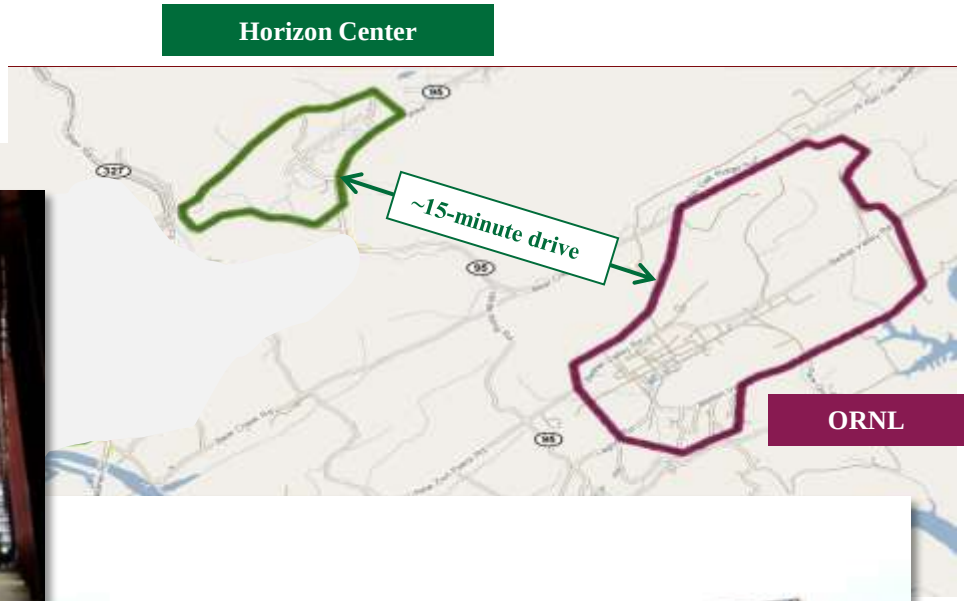
Features and Functions

- Oxidation Ovens
  - Multi-Flow Allowing Comparison of all major oxidation flow techniques
  - Compatible with Sulfur Off Gassing
  - Continuous Bulk Materials Processing
  - Belt System through lower chambers – 4 zone belt processing
- LT Furnace
  - Enabled up to 1000 Degrees-C
  - Allows for Multiple Atmospheres, N2, CO, H2O
  - Continuous Belt System for Bulk Materials
- HT Furnace
  - Enabled up to 2000 Degrees-C
  - Allows for Multiple Atmospheres, N2, Ar
  - Continuous Belt System for Bulk Materials

Oak Ridge National Laboratory
Carbon Fiber Technology Facility
General Arrangement & System Layout

ORNL - CFTF Overview

Forecast to commence operations in Feb 2013



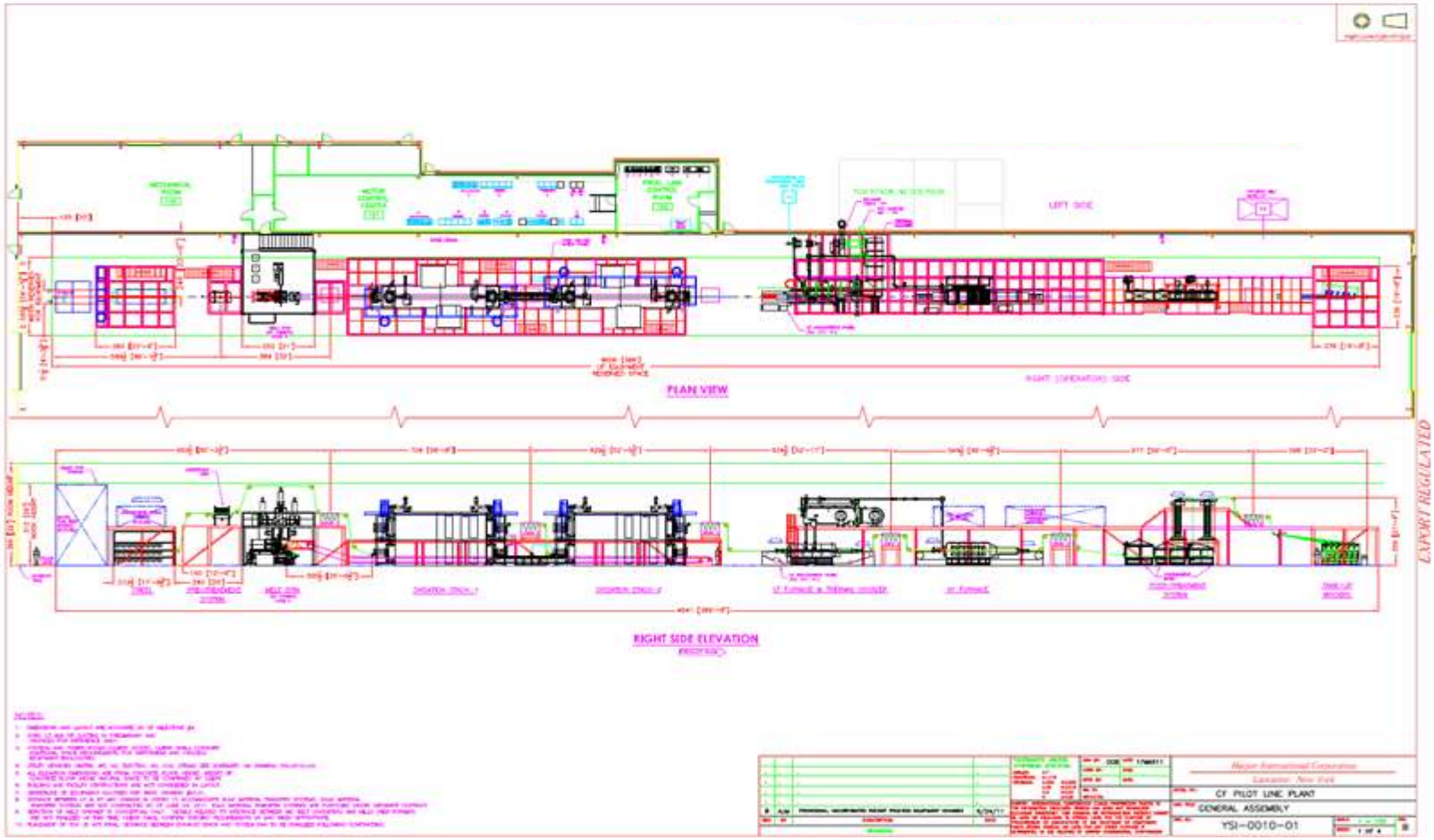
42,000 square feet of production, lab, office, and support areas

Images Courtesy of ORNL

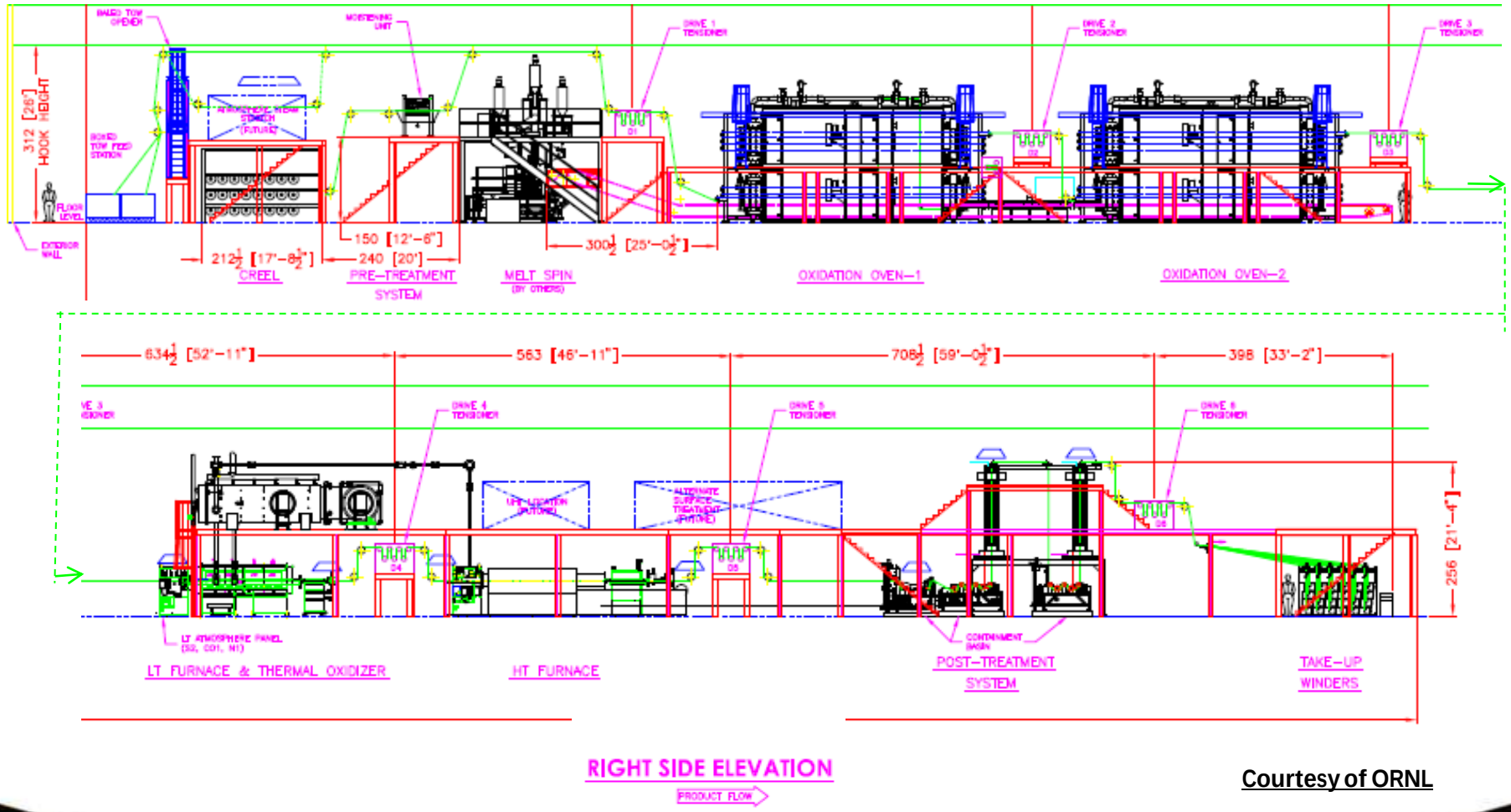
ORNL – CFTF
October 2011

Image
Courtesy of ORNL

ORNL - CFTF
General Arrangement / Layout



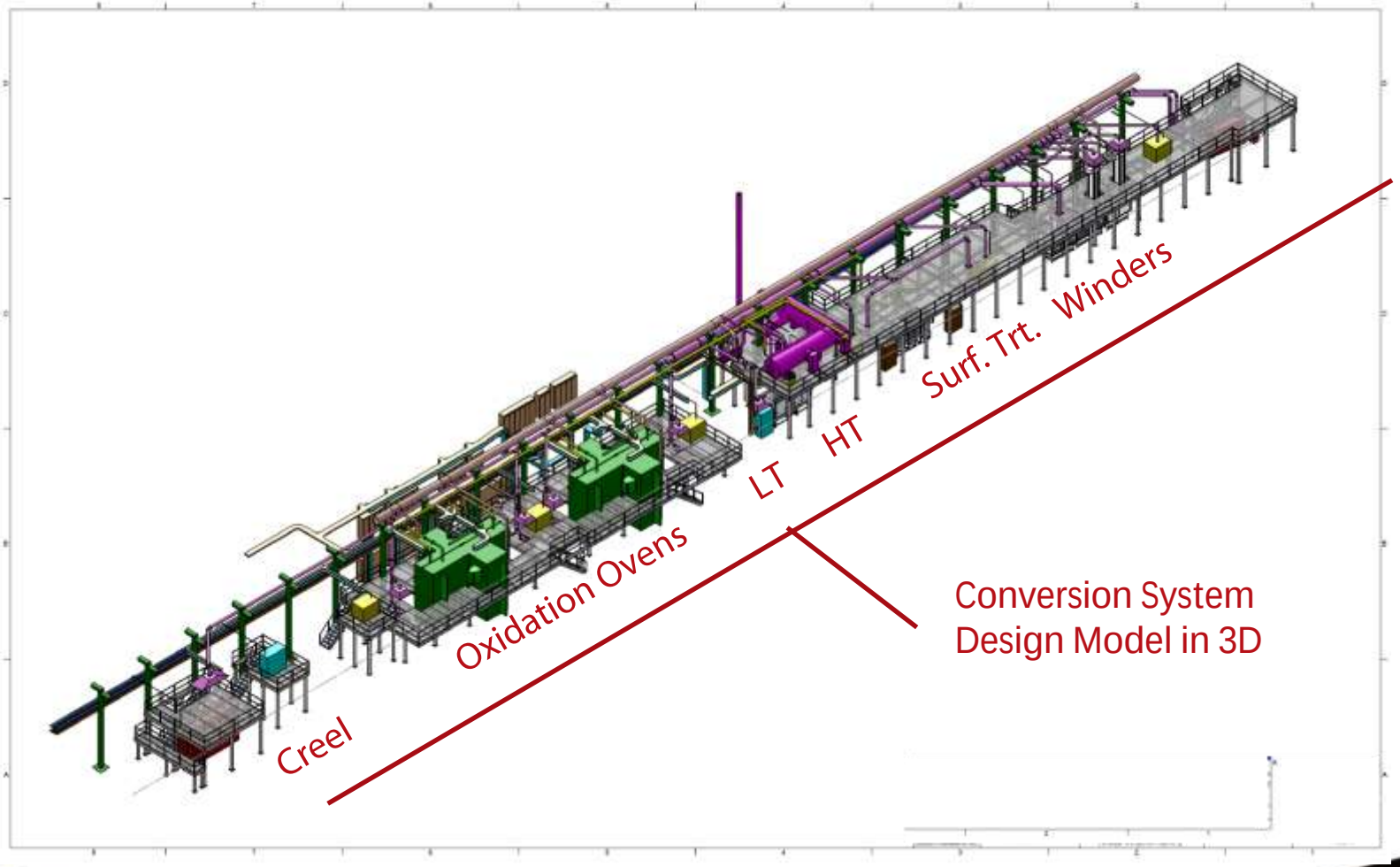
ORNL - CFTF
General Arrangement / Layout



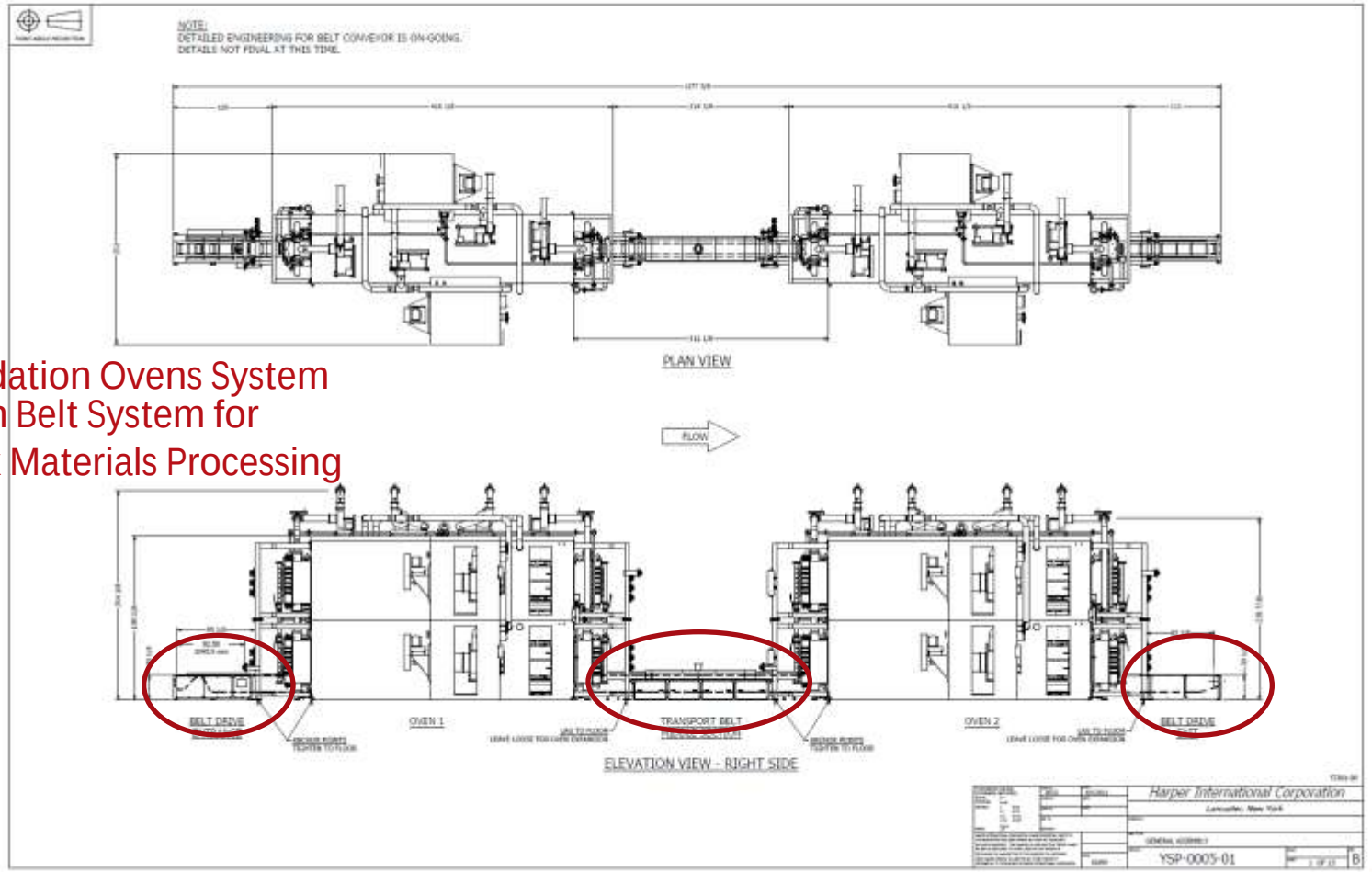
Courtesy of ORNL

Update -- Approximately 375 feet in length

ORNL - CFTF
General Arrangement / Layout



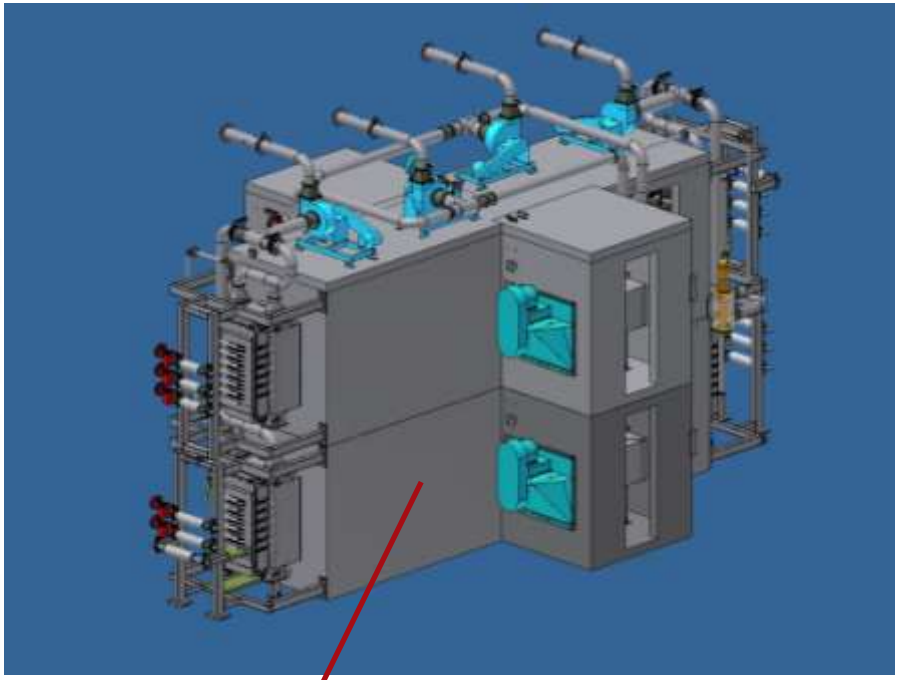
ORNL - CFTF
General Arrangement / Layout



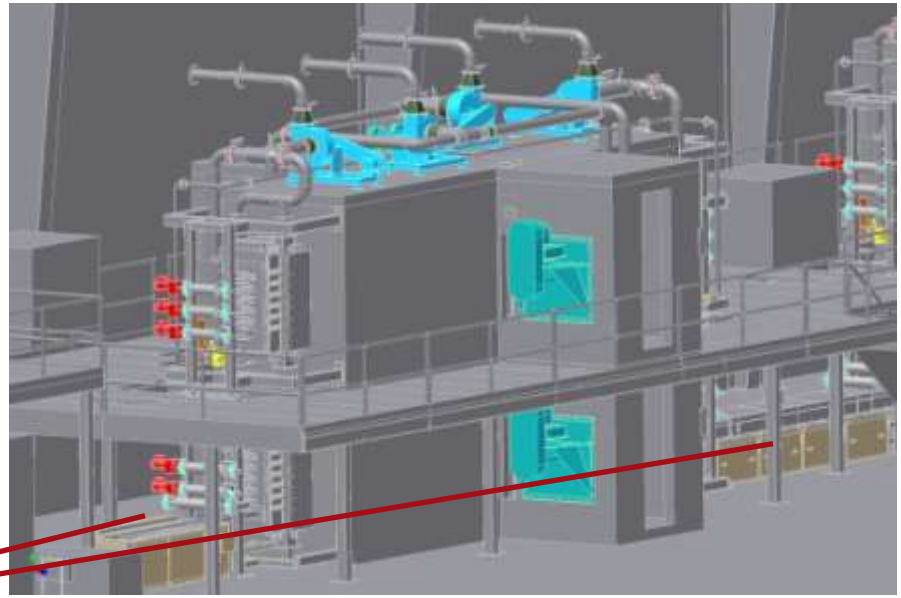
Oxidation Ovens System
With Belt System for
Bulk Materials Processing

Oxidation Ovens

ORNL - CFTF
General Arrangement / Layout



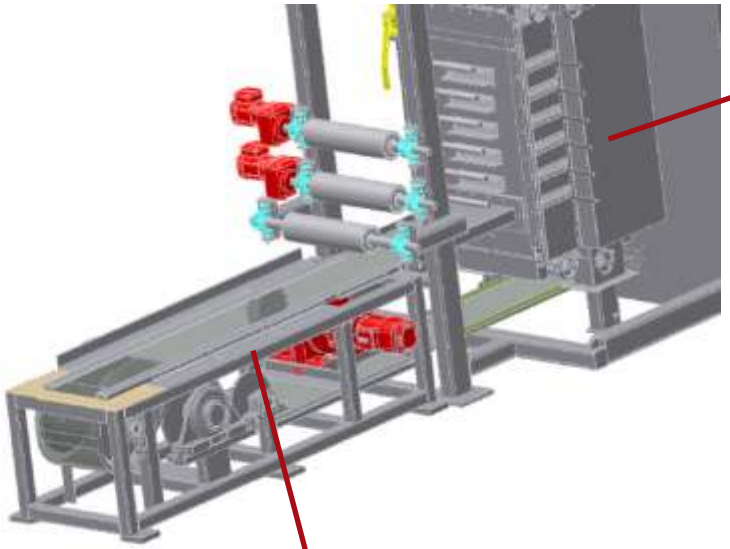
Oxidation Ovens Stack



Installed with Belt System for
Bulk Materials Processing

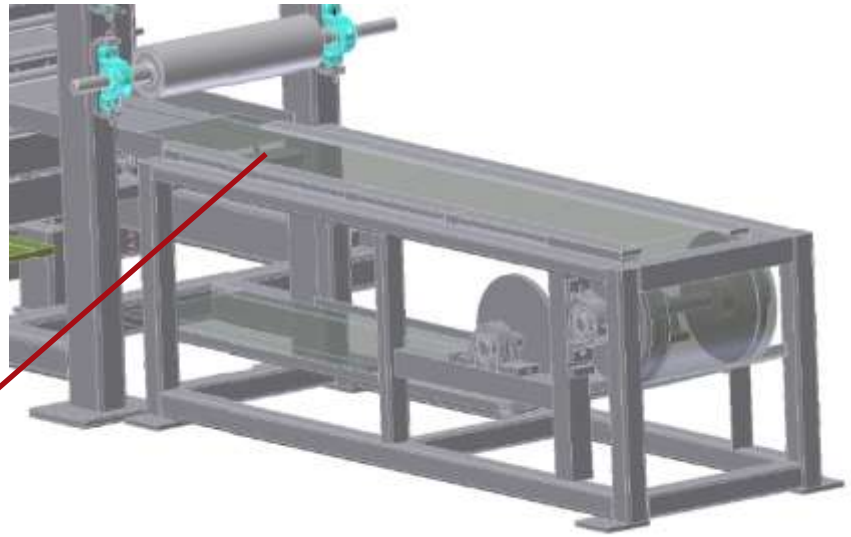
Oxidation Ovens

ORNL - CFTF
General Arrangement / Layout



End Seal for Continuous Filamentary (Tow) Operation

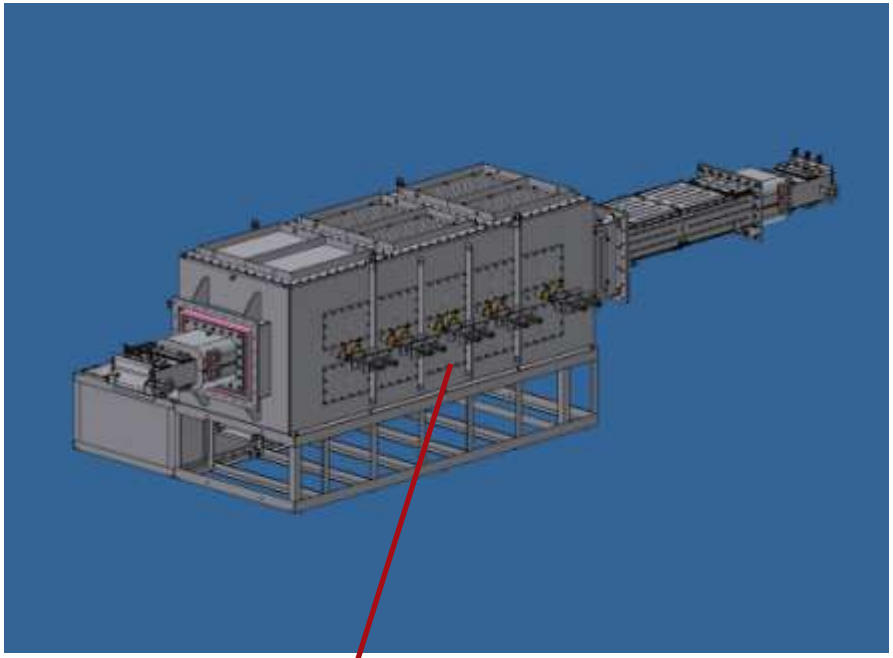
Lay-Down Feed Belt & Exit Belt



Oxidation Ovens

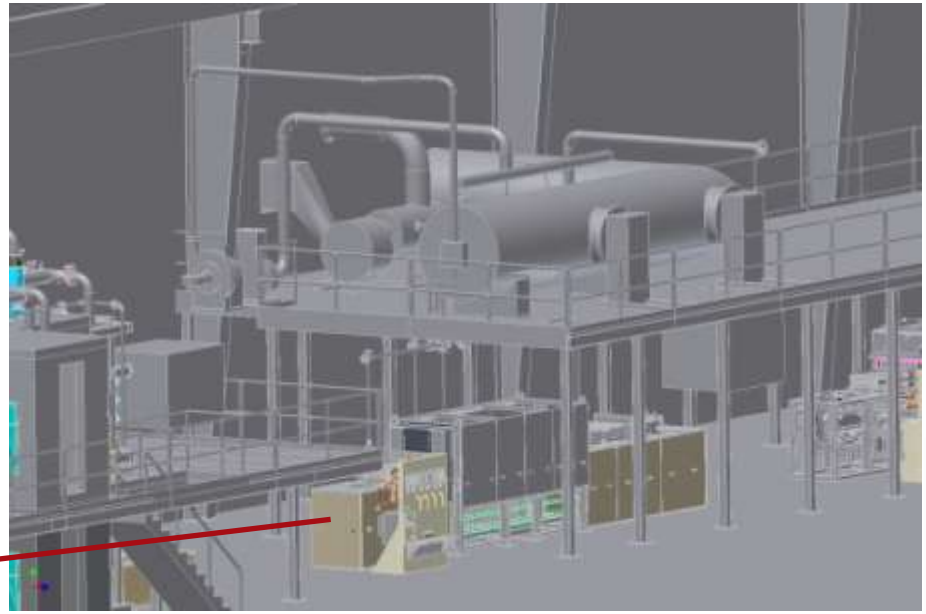
Ends Seals, Belts

ORNL - CFTF
General Arrangement / Layout



LT Furnace

Installed with Belt System for
Bulk Materials Processing
And in Proximity to Thermal
Oxidizer



LT Furnace

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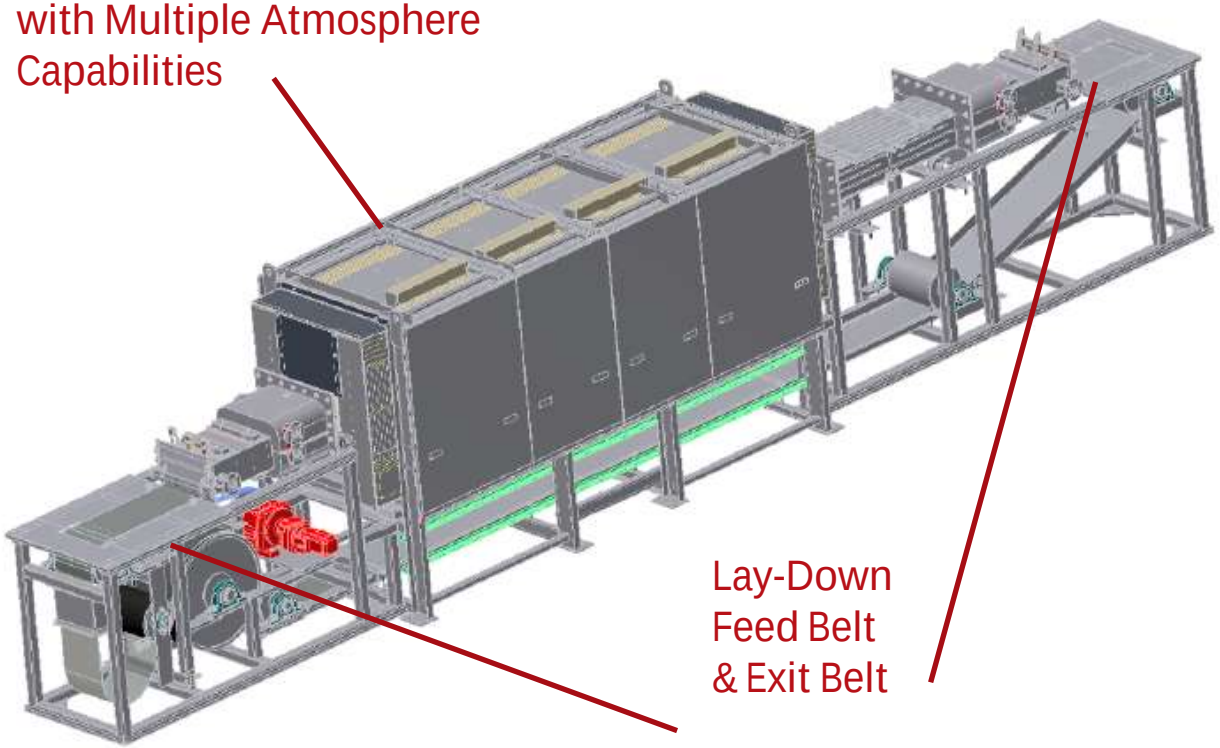
General Arrangement / Layout



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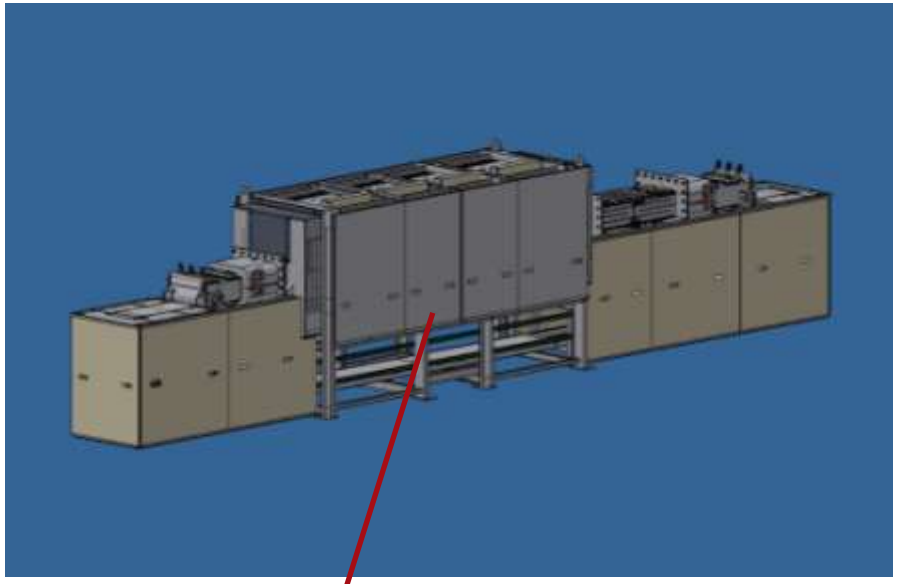
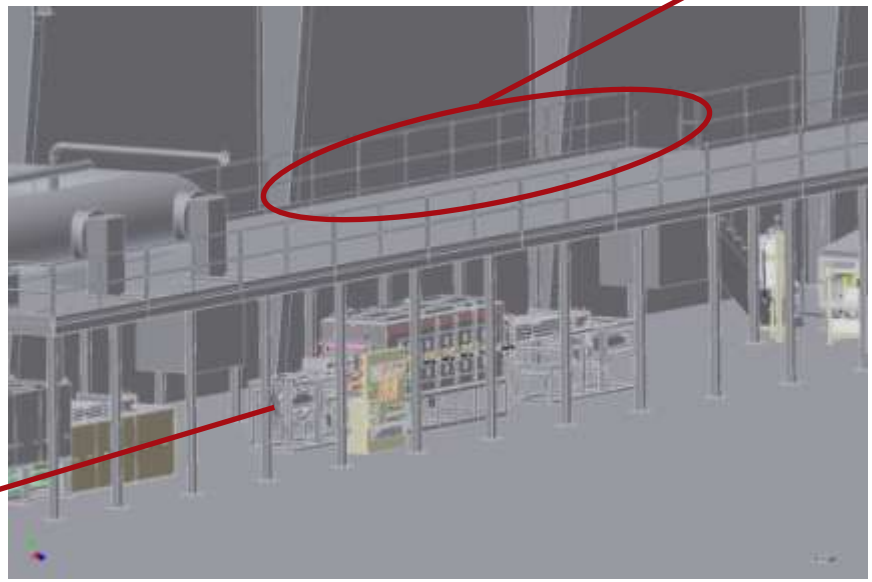


HT Furnace

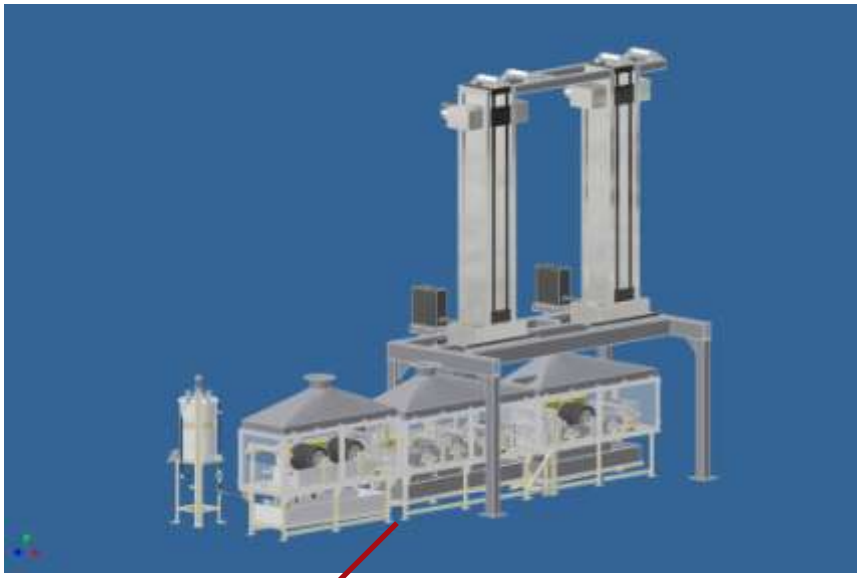
Installed with Belt System for
Bulk Materials Processing
And in Proximity to Thermal
Oxidizer

Space Allocation for
Future Addition of UHT Furnace



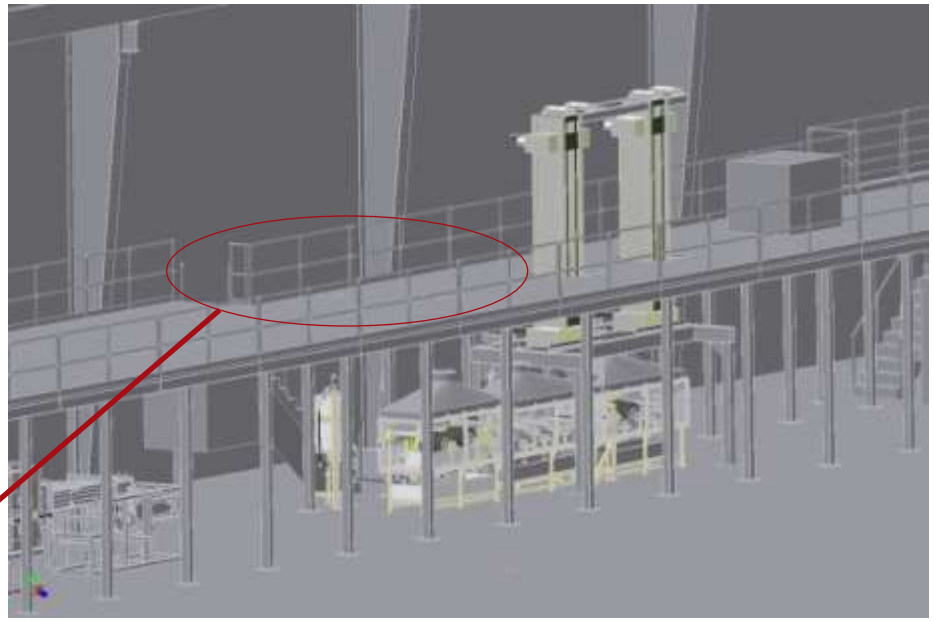
HT Furnace

ORNL - CFTF
General Arrangement / Layout



Traditional Surface Treatment System

Installed with Space Reserved for Future Addition of Advanced Surface Treatment Techniques



Surface Treatment

Oak Ridge National Laboratory
Carbon Fiber Consortium

ORNL Carbon Fiber Consortium

- ORNL has created a Consortium for Carbon Fiber research structured around the CFTF Project
- Inaugural Meeting – September 2011
- Harper has joined the Consortium with the Following Objectives
  - To Participate in ongoing discussions around the use of the CFTF
    - Help users meet specific and distinct processing needs
    - Customization of process equipment
  - Emerging Processing (Future) Techniques are likely to be structured around Specific Needs of Materials Programs
  - Access to Broad Value Stream From Material Producers to End Users

- For More Information Visit: http://www.cfcomposites.org/index.shtml or contact CFTF@ORNL.GOV

Thank You for Your Attention