



# **Polyacrylonitrile (PAN) Carbon Fibers Industrial Capability Assessment**

**OUSD(AT&L) Industrial Policy**

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## EXECUTIVE SUMMARY

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Section 832 of the FY05 National Defense Authorization Act directs the Secretary of Defense to submit a report to the Committees on Armed Services of the Senate and the House of Representatives by October 28, 2005. The report is to address the domestic and international industrial structure that produces Polyacrylonitrile (PAN) carbon fibers, current and anticipated market trends for the product, and how the trends compare to the assessment as reported by the Secretary of Defense in January 2001.

This report describes PAN carbon fibers, the domestic and international market structure, and current and anticipated market trends. Much of the data submitted to generate this report and a decision on Section 832 is proprietary. A comparison of this report and the 2001 report is provided under separate cover. Specifically, this report addresses:

- Worldwide market trends for PAN carbon fiber
  - Current/projected capacity, demand, capacity utilization, and economic outlook
- U.S.-located producers who meet the requirements of the current Defense Federal Acquisition Regulation Supplement (DFARS) restrictions (PAN carbon fibers manufactured in the United States, its outlying areas, or Canada using PAN precursor produced in the United States, its outlying areas, or Canada).
  - Location, capacity, current and projected capacity utilization, current and projected business base (particularly Department of Defense (DoD) programs for which they are qualified), current and projected financials (to the extent they are available).
- Other U.S.-located suppliers of PAN carbon fiber who do not meet the DFARS restrictions (perhaps because the precursor is not produced in the United States)
  - Location, capacity, current and projected capacity utilization
- Non-U.S.-located suppliers of PAN carbon fiber.
  - Location, capacity, current and projected capacity utilization

For the past five years, demand for PAN carbon fiber did not show significant growth due to the slumping aerospace industry and weak economic factors within the three major consuming regions (Pacific Rim, Europe, and North America). However, recently, demand has increased and is forecasted to grow six to ten percent per year for the next five years. Although the industrial market, particularly the automotive sector, will continue to represent the majority of PAN carbon fiber applications, the outlook for the aerospace industry also has improved and PAN carbon fiber is projected to penetrate deeper into this market.

Demand also is projected to grow within the recreational and sporting goods markets.

In response to growing demand, major PAN carbon fiber producers have expanded or have capital investment plans to expand their precursor (feedstock) and PAN carbon fiber manufacturing capacities. Worldwide nameplate capacity increased by only 2.3 percent per year from 2003 to 2005. However, it is projected to reach 48,500 tons by 2007, a 41 percent growth from 2003 and 35 percent growth from 2005. DFARS compliant suppliers (defined as those that procure their precursor from domestic producers) did not add capacity from 2003 to 2005, but are expected to more than double their capacity from 4,650 tons to 9,550 tons by 2007. DFARS compliant suppliers are forecasted to produce 19.6 percent of worldwide capacity in 2006. Including U.S. non-DFARS compliant suppliers, the United States will produce 48.6 percent of the worldwide nameplate capacity by 2007.

Currently there are two DFARS compliant manufacturers of PAN carbon fiber in the United States (Hexcel and Cytec). Hexcel produces up to "intermediate" modulus and Cytec up to "standard" modulus. Toray Carbon Fibers America is expanding capacity and constructing a precursor facility in the United States that will be operational in early 2006, which will provide a third source. Current DoD aerospace programs require at least intermediate modulus, while older programs use standard modulus. Future DoD programs likely will require high modulus or ultra high modulus, which is currently manufactured only in Japan.

The outlook for PAN carbon fiber producers is strong. The two DFARS compliant producers are operating at very high levels of capacity utilization. The carbon fibers segments of these U.S. firms are posting strong profits. Domestic sources have capability and capacity to support current DoD requirements and the addition of Toray Carbon Fibers America in 2006 introduces additional domestic capabilities.

## INTRODUCTION

Polyacrylonitrile (PAN) is a white fiber formed by extruding and processing an acrylonitrile-based polymer that is used as the feedstock (precursor) for production of carbon fiber. PAN carbon fibers are combined with plastic resins to produce a composite prepreg. Composite prepreps, in tape or fabric form, are then fabricated into a composite structure. PAN is the key ingredient to obtain the high performance required for aerospace applications. PAN carbon fibers are qualified (proven satisfactory for specific applications) separately from the prepreg, and are then qualified again as part of the prepreg. PAN properties (mostly, the result of proprietary precursor fiber chemistry, fiber sizings, coatings, and production processes) are key in establishing the high tensile strength and tensile modulus (stiffness) characteristics important in composite structures for defense and commercial aircraft applications. Typical aerospace-grade tow<sup>1</sup> size ranges from 1K to 12K (regular tow). Industrial grade tow size ranges from 24K and up (large tow). Carbon fiber tow consists of thousands of continuous untwisted filaments, with the filament count designated by a number followed by "K", indicating multiplication by 1,000 (e.g., 12K indicates a filament count of 12,000).

Typical carbon fibers are available with a "commercial" grade (28 to 31 modulus<sup>2</sup> or msi), "standard" grade (32 to 35 msi), and "intermediate" grade (38 to 44 msi). Current Department of Defense (DoD) aerospace programs require at least intermediate modulus, while older programs use standard modulus. Future DoD programs most likely will require "high" modulus (48 to 60 msi) or "ultra high" modulus (above 60 msi), which is currently manufactured only in Japan. Hexcel currently produces up to intermediate modulus and Cytec produces only up to standard modulus. Table 1 below illustrates defense and space applications for PAN carbon fiber.

| <b>TABLE 1: PAN CARBON FIBER DEFENSE AND SPACE APPLICATIONS</b>              |  |
|--|--|
| <b>Fighter Aircraft</b>  | A-6, EF 18-G, F-15, F-16, F-18 E/F, F/A-22, JSF  |
| <b>Transports</b>  | C-17, C-130J, T-45A  |
| <b>Rotorcraft</b>  | V-22, AH-64, CH-47, MH-60, UH-60, Light Utility  |
| <b>Launch Vehicles</b>   | Delta II/III/IV, Atlas V, EELV, Pegasus, Sea Launch  |
| <b>Missiles</b>  | THAAD, JASSM, Trident II (D-5), Patriot, Minuteman, Javelin  |
| <b>Naval</b>   | LDP-17, DD-21/DD(X), DDG-51  |
| <b>Other</b>   | Sabots, MK-125, Satellites, Space Station, Space Shuttle, Obscurants, Global Hawk, Predator, Boeing 767, Boeing 787, Airbus A380 |
| Source: Defense Contract Management Agency (DCMA) Industrial Analysis Center |  |

<sup>1</sup> Tow is defined as the continuous ordered assembly of essentially parallel, collimated filaments, normally continuous filaments without twist.

<sup>2</sup> Modulus, also referred to as "msi", is the mathematical value that describes the stiffness of a material by measuring its deflection or change in length under loading.

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## INDUSTRIAL INFRASTRUCTURE

### WORLDWIDE MARKET

Worldwide PAN carbon fiber nameplate capacity is 35,904 tons and is projected to reach 48,500 tons by 2007, a 41 percent growth from 2003 and 35 percent from 2005. Defense Federal Acquisition Regulation Supplement (DFARS) compliant producers<sup>3</sup> provide 12.9 percent (4,650 tons) and are forecasted to increase to 19.6 percent with the introduction of new capacity in 2006. Including non-DFARS compliant producers, the United States will produce 48.6 percent of the worldwide nameplate capacity by 2007.

For the past five years, demand for PAN carbon fiber did not show significant growth due to the slumping aerospace industry and weak economic factors within the three major consuming regions (Pacific Rim, Europe, and North America). Recently, demand has increased and is forecasted to grow six to ten percent per year for the next five years. Although the industrial market, particularly the automotive sector, will continue to represent the majority of PAN carbon fiber applications, the outlook for the aerospace industry also has improved and PAN carbon fiber is projected to penetrate deeper into this market. Demand also is projected to grow within the recreational and sporting goods markets.

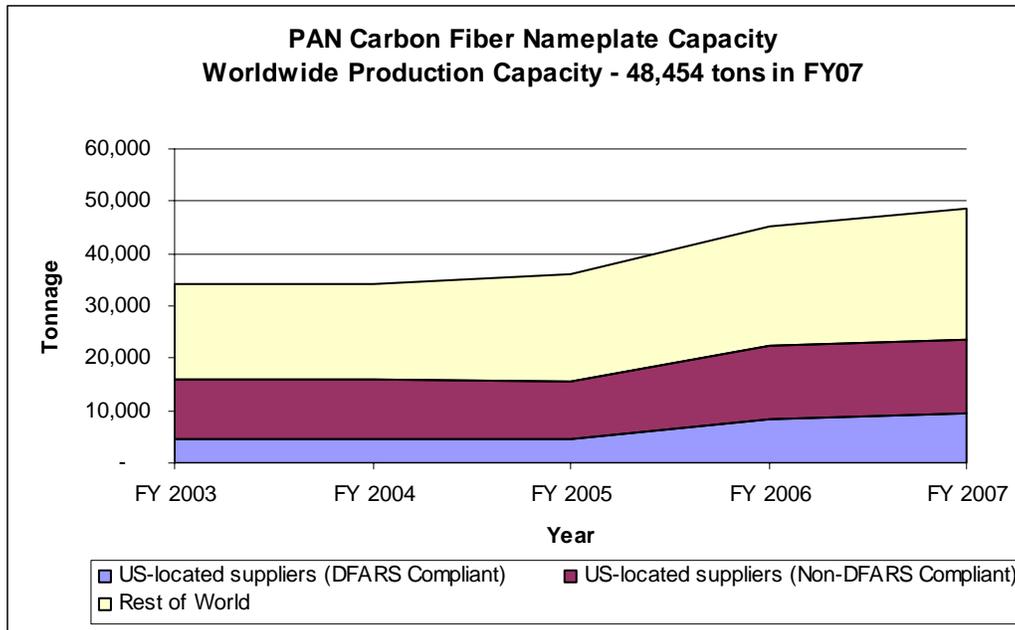
Some manufacturers in this market have responded to increased demand by expanding their precursor and PAN carbon fiber manufacturing capabilities. Some producers also have capital upgrade plans to increase capacity. Worldwide nameplate capacity increased only by 2.3 percent per year from 2003 to 2005. However, it is projected to increase by 35 percent between 2005 and 2007. From 2003 to 2005, U.S. DFARS compliant suppliers did not add capacity, however, they have capital investment plans to almost double their capacity by 2007. Table 2 and Graph 1 illustrate worldwide nameplate production capacity.

**TABLE 2: WORLDWIDE NAMEPLATE PRODUCTION CAPACITY (TONS)**

|   | FY 2003       | FY 2004       | FY 2005       | FY 2006       | FY 2007       |
|---|---------------|---------------|---------------|---------------|---------------|
| <b>U.S. Located Suppliers (DFARS Compliant)</b>           | 4,600         | 4,600         | 4,650         | 8,500         | 9,550         |
| <b>Other U.S. Located Suppliers (Non DFARS Compliant)</b> | 11,300        | 11,300        | 10,800        | 14,000        | 14,000        |
| <b>Non-U.S. Located Suppliers</b>                         | 18,378        | 18,378        | 20,454        | 22,704        | 24,904        |
| <b>Total World Nameplate Producti</b>                     | <b>34,278</b> | <b>34,278</b> | <b>35,904</b> | <b>45,204</b> | <b>48,454</b> |

Sources: (1) DMCA Industrial Analysis Center's analyses of company surveys, press releases and interviews.  
 (2) Composite Manufacturing – January 2005 – "High Performance Materials Expect Strong Year," Bill Benjamin and Chris Red.

<sup>3</sup> In accordance with DFARS Part 252.225-7022 Restriction on Acquisition of Polyacrylonitrile (PAN) Carbon Fiber, "...(b) PAN carbon fibers contained in the end product shall be manufactured in the United States or Canada using PAN precursor produced in the United States or Canada."



**Graph 1: PAN Carbon Fiber Nameplate Capacity**

Despite the increase in PAN carbon fiber production capacity in North America (particularly the United States) and Europe, Pacific Rim firms will continue to be the world leader in PAN carbon fiber production and will continue to export to Europe and North America.

**U.S. LOCATED PAN FIBER PRODUCERS (DFARS COMPLIANT)**

Currently there are two DFARS compliant suppliers of PAN carbon fiber in the United States (Hexcel and Cytec). Hexcel produces up to intermediate modulus and Cytec up to standard modulus, although Cytec is attempting to qualify an intermediate modulus. Current DoD aerospace programs require at least intermediate modulus, while older programs use standard modulus. Future DoD programs are planned to require high modulus or ultra high modulus, which is currently manufactured only in Japan.

Toray Carbon Fibers America is constructing a facility in the United States to manufacture precursor that will be operational in early 2006. Table 3 shows the locations of precursor and PAN carbon fiber production capabilities.

| <b>TABLE 3: LOCATION OF U.S. LOCATED PRECURSOR AND PAN CARBON FIBER SUPPLIERS (DFARS COMPLIANT)</b> |                    |                                   |                                    |
|---|--------------------|-----------------------------------|------------------------------------|
| <b>Manufacturer</b>   | <b>Hexcel</b>      | <b>Cytec Engineered Materials</b> | <b>Toray Carbon Fibers America</b> |
| <b>Ownership</b>  | Hexcel (U.S.A.)    | Cytec Industries (U.S.A.)         | Toray (Japan)                      |
| <b>Precursor Location</b>   | Decatur, AL        | Greenville, SC                    | Decatur, AL*                       |
| <b>PAN Carbon Fiber Location</b>  | Salt Lake City, UT | Greenville, SC<br>Rock Hill, SC   | Decatur, AL                        |
| Source: DCMA Industrial Analysis Center   |                    |                                   |                                    |

\* In FY 2006, Toray Carbon Fibers America will add precursor capabilities to their Decatur, AL, location.

DFARS compliant suppliers did not add capacity from 2003-2005, but will more than double their capacity to 9,550 tons by 2007.

### **HEXCEL CORPORATION**

Hexcel Corporation, headquartered in Stamford, Connecticut, was founded in 1946. Hexcel Corporation and its subsidiaries develop, manufacture, and market lightweight, high performance reinforcement products, composite materials, and composite structures for use in commercial aerospace, industrial, space and defense, and electronics markets. In 1996 Hexcel acquired the worldwide composites business of Ciba-Geigy and the composite products division of Hercules. This was followed in 1997 by the acquisition of Fiberite's satellite prepreg product line. Hexcel operates 22 manufacturing sites in nine countries.

Hexcel Corporation's Salt Lake City (SLC) Fibers Plant, located in West Valley City, UT, manufactures carbon fibers and prepreg (Matrix Systems) for aerospace, recreation, and industrial applications. Hexcel manufactures carbon fiber from PAN precursor it produces at its Decatur, AL, facility. Hexcel produces regular tow PAN based carbon fibers. The Decatur facility is the sole qualified domestic producer of PAN precursor intermediate modulus used in the F-18 E/F, F-22, JSF, C-17, and V-22 military aircraft. The company currently is qualified to supply materials to a broad range of over 80 military aircraft and helicopter programs. Hexcel uses approximately 50 percent of the carbon fiber it produces and sells the remainder of its output to third-party customers.

The SLC facility is situated on 117 acres and utilizes 13 buildings, with 450,000 square feet of space. The SLC facility has six operating PAN carbon fiber production lines and the company has capital investment plans to increase production by adding two new lines at SLC and also expand precursor capabilities by adding one new spinning line in Decatur by 2008. SLC operates three shifts per day, seven days per week. Each of the active PAN carbon fiber production lines runs a process beginning with creel,<sup>4</sup> oxidation

<sup>4</sup> A "creel" is a frame for holding spools or bobbins in a spinning machine.

that progresses the PAN fibers through a series of incrementally hotter ovens to burn off impurities, carbonization that heats the fiber to 1,300 degrees, sizing which adds tension to conform the product to customer strength specifications, then winding the treated PAN onto spools where it is then packaged and shipped. The plant has a fully automated inventory system. Other buildings at the facility produce resin and solvent coating and hot melt prepreg (impregnated fiber with the resin) which is rolled onto spools with backing that is packaged and shipped to customers. There is also a fully automated freezer which is used to stock prepreg inventory prior to being shipped. The company has used their own investment for expansion and qualification processes. The Decatur facility is situated on 28 acres and utilizes 6 buildings, with 140,000 square feet of space

In 2004, 38 percent of output supported DoD. That is expected to increase to 47 percent by 2010.

#### Hexcel Financial Assessment

Hexcel Corporation (NYSE: HXL), reports financially in three operating segments: Reinforcements, Composites, and Structures. The Salt Lake City Fibers Plant's operating results are reported within the Composites business segment. The Composites business segment is the most profitable Hexcel business segment.

For the fiscal year (FY) ending December 31, 2004, Hexcel reported sales of \$1,074.5 million (an increase of 19.8 percent over the previous year), operating income of \$88.8 million, and net income \$3.4 million versus FY 2003 sales of \$896.9 million, operating income of \$60.0 million, and a net loss of \$(20.7) million. Earnings per share in 2004 were \$0.08 versus a loss per share of \$(0.54) in 2003. Approximately 19.3 percent of FY 2004 sales were to Boeing with 20.7 percent representing sales to EADS. Sales increased in the Reinforcements and Composites segments, while Structures saw a 10 percent reduction. All operating segments reported profits. Operating margins improved at Reinforcements and Composites and were flat at Structures. The Composites segment reported 2004 sales of \$683.9 million and operating income of \$89.1 million versus 2003 sales of \$584.8 million and operating income of \$66.8 million, increases of 17 percent and 33 percent respectively. Operating margin improved to 13.0 percent, up from 11.4 percent in 2003. Table 4 shows the segment revenue contributions and operating profit margins in 2003 and 2004.

**TABLE 4: HEXCEL SEGMENT REVENUE AND OPERATING MARGINS (PERCENTAGE)**

| Segment        | 2004 Revenue Contribution | 2004 Operating Profit Margin | 2003 Revenue Contribution | 2003 Operating Profit Margin |
|----------------|---------------------------|------------------------------|---------------------------|------------------------------|
| Reinforcements | 29.7                      | 12.4                         | 26                        | 7.0                          |
| Composites     | 63.6                      | 13.0                         | 65                        | 11.4                         |
| Structures     | 6.6                       | 5.3                          | 9                         | 5.3                          |

Source: Hexcel Corporation's FY2004 Form 10-K, page 105.

For the first quarter-2005 (1Q2005), Hexcel reported sales of \$290.6 million, operating income of \$32.9 million, and a net loss of \$(24.7) million versus prior year comparable sales of \$262.8 million, operating income of \$23.7 million, and net income of \$8.1 million. Results in 2005 were impacted by a non-operating expense charge of \$40.3 million related to the early retirement of debt. The company refinanced substantially all of its debt during the quarter which should reduce interest expenses by \$4.0 million per quarter. Excluding the charge, net income would have been \$17.9 million in 1Q2005. Sales were up 10.6 percent and operating income increased 38.8 percent with operating margin increasing to 11.3 percent from nine percent in the first quarter of 2004.

Table 5 illustrates Hexcel financial performance.

| <b>TABLE 5: HEXCEL FINANCIAL PERFORMANCE</b>                |             |             |             |
|---|-------------|-------------|-------------|
| <b>Ownership: Hexcel Corporation</b>                        |             |             |             |
| <b>Financial</b>  | <b>2004</b> | <b>2003</b> | <b>2002</b> |
| Sales (\$M)   | \$1,074.5   | \$896.9     | \$850.8     |
| Net Income (\$M)  | \$3.4       | \$(20.7)    | \$(13.6)    |
| Net Margin (%)  | 0.3%        | (2.3%)      | (1.6%)      |
| Operating Margin (%)  | 8.3%        | 6.4%        | 7.1%        |
| Current Ratio   | 1.73        | 1.86        | 0.32        |
| LT Debt to Equity (%)                                       | (1,763.9)   | (515.3%)    | 0           |
| U.S. Govt. Percent of Total                                 | 18%         | 20%         | 17%         |
| Cash from Operations (\$M)                                  | \$85.9      | \$46.9      | \$65.9      |
| Net Cash Flow (\$M)   | \$15.5      | \$33.5      | \$(3.4)     |
| Source: Hexcel Corporation's FY2004 Form 10-K, pages 67-70. |             |             |             |

## **CYTEC INDUSTRIES**

Cytec Industries headquartered in West Patterson, NJ, is a specialty chemicals and materials technology company for global markets, including aerospace, coatings, mining, plastics and water treatment. Cytec Industries has 41 manufacturing facilities worldwide. The business was formally owned by Union Carbide, and purchased by Amoco in 1986. In 1999 the business was purchased by BP. Cytec Industries purchased the business from BP in September 2001.

Cytec Industries operates two carbon fiber facilities, one in Greenville, SC, and one in Rock Hill, SC. The Greenville facility located on 140 acres has two PAN carbon fiber/precursor production lines and also houses the research and development functions. Cytec is currently investigating the possibility of expanding their facilities. In 2004, 17 percent of Cytec's output supported DoD. That is expected to decrease to 14 percent by 2007. The company is unsure what the DoD demand will be in the out years.

The PAN carbon fiber produced at the Greenville facility is standard modulus (32-35 msi). Cytec produces regular tow PAN based carbon fibers. The company is in the process of trying to qualify an intermediate modulus (38-44 msi) since most DoD aerospace programs require intermediate. The Greenville facility also has a pitch carbon fiber line. Pitch carbon fiber is produced by carbonization of oil/coal pitch precursor. It has high heat conductivity, electric conductivity, and also high tensile strength and high elastic modulus. Cytec purchases intermediate modulus from Hexcel Carbon Fibers, Salt Lake City, UT. Cytec using Hexcel PAN carbon fibers, is the sole prepreg source for the F-18 E/F, F-22, and JSF programs. Cytec and Hexcel compete aggressively to supply prepreg for defense and commercial aircraft applications. Cytec's major customers include Cytec Engineered Materials, Hexcel, Sigmalex, Fabric Development, Textile Products, and BGF. The major end use customers include Boeing (C-17, AH-64, 737, and 777) and Boeing subcontractors, business jets for Embraer, Bombardier, Cessna, and Global Express. The company also supports engine manufacturers; General Electric, Rolls Royce, and Pratt and Whitney. Lockheed Martin (C-130), Northrop Grumman (Global Hawk), and other aircraft/aerospace manufacturers are also supported. Rock Hill utilizes precursor produced in Greenville.

### Cytec Financial Assessment

Cytec Carbon Fibers LLC, Piedmont, SC, is a division of Cytec Industries, Inc. (CYT: NYSE). CYT operates as a specialty chemicals and materials company that develops products for global markets including aerospace, water treatment and mining, automotive, industrial coatings, plastics, and chemical intermediates. In FY 2004, the company operated in four segments: Specialty Materials, Building Block Chemicals, Specialty Chemicals: Performance Products, and Specialty Chemicals: Water & Industrial Process Chemicals. Cytec Carbon Fibers LLC's financial results are reported within the Specialty Materials segment, the most profitable of Cytec's business segments. Site specific financial information for Cytec Carbon Fibers was not available.

For the fiscal year ending December 31, 2004, Cytec reported sales of \$41.7 billion, earnings from operations of \$159.6 million, and net income of \$116.2 million versus FY 2003 sales of \$1.5 billion, operating earnings of \$141.1 million, and net income of \$77.4 million. Earnings per Share improved 25 percent to \$2.94 in FY 2004, up from \$2.34 the previous year. All operating segments reported increased sales and were profitable. Operations outside the United States accounted for 53 percent of total sales and 61 percent of operating profits in 2004. The Specialty Materials segment which includes Cytec Carbon Fibers reported sales for FY 2004 of \$487.0 million and operating earnings of \$84.2 million versus FY 2003 sales of \$408.7 million and operating earnings of \$66.3 million, increases of 19 percent and 27 percent respectively. Operating margin was a healthy 17.3 percent, up from 16.2 percent.

Table 6 illustrates Cytec segment revenue contributions and operating profit margins for 2003 and 2004.

| <b>TABLE 6: CYTEC SEGMENT REVENUE AND OPERATING MARGINS (PERCENTAGE)</b> |  |   |  |   |
|--|--|---|--|---|
| <b>Segment</b>   | <b>2004<br/>Revenue<br/>Contribution</b> | <b>2004<br/>Operating<br/>Profit Margin</b> | <b>2003<br/>Revenue<br/>Contribution</b> | <b>2003<br/>Operating<br/>Profit Margin</b> |
| Specialty Materials  | 28.3                                     | 17.3  | 27.8                                     | 16.2  |
| Building Block<br>Chemicals  | 15.1                                     | 4.3   | 14.3                                     | 7.3   |
| Performance Products   | 32.8                                     | 10.1  | 33.3                                     | 7.6   |
| Water & Industrial<br>Process Chemicals                                  | 23.8                                     | 5.2   | 24.6                                     | 5.6   |
| Source: Cytec Industries 2004 Form 10-K, page 52.                        |  |   |  |   |

Revenue is well dispersed among the four segments with no segment exceeding more than 33 percent of volume. Margins are varied and trends are also mixed. As can be seen in Table 6 above, the Specialty Materials Segment is the most profitable. In addition, Wall Street projects a 10 - 20 percent revenue growth rate in 2005 based on continued growth in military use and sales to Airbus.

In October 2004, CYT agreed to acquire the Surface Specialties business of UCB Group, a Belgium biopharmaceutical and specialty chemicals company, for \$1.8 billion in cash and stock, subject to regulatory approvals. The acquisition was completed in February 2005. This business makes resins and additives for coatings and had sales of \$1.2 billion in 2003. Wall Street expects sales to be accretive to earnings in 2005. This acquisition should complement the ten percent projected gain in CYT organic revenues.

Following the acquisition, Cytec Industries reorganized. Cytec Specialty Materials was renamed Cytec Engineered Materials; Building Block Chemicals remains unchanged. The new Cytec Surface Specialties segment includes the acquired Surface Specialties product lines plus Cytec's previously existing Coating Chemicals & Performance Chemicals product lines. The new Cytec Performance Specialties segment includes the

Water Treatment Chemicals, Mining Chemicals, Phosphine & Phosphorous Specialties, Polymer Additives and Specialty Additives product lines.

Table 7 illustrates Cytec's financial performance.

| <b>TABLE 7: CYTEC FINANCIAL PERFORMANCE</b>           |             |             |             |
|---|-------------|-------------|-------------|
| <b>Ownership: Cytec Industries, Inc.</b>              |             |             |             |
| <b>Financial</b>                                      | <b>2004</b> | <b>2003</b> | <b>2002</b> |
| Sales (\$M)   | \$1,721.3   | \$1,471.8   | \$1,346.2   |
| Net Income (\$M)                                      | \$126.1     | \$77.4      | \$79.3      |
| Net Margin (%)  | 7.3%        | 5.3%        | 5.9%        |
| Operating Margin (%)                                  | 9.3%        | 9.6%        | 8.9%        |
| Current Ratio   | 1.8         | 2.1         | 1.4         |
| LT Debt to Equity (%)                                 | 33.1%       | 55.1%       | 34.3%       |
| Cash from Operations (\$M)                            | \$167.4     | \$132.4     | \$211.6     |
| Net Cash Flow (\$M)                                   | \$72.7      | \$41.1      | \$126.4     |
| Source: Cytec Industries 2004 Form 10-K, pages 26-29. |             |             |             |

#### **TORAY CARBON FIBERS AMERICA**

Toray Industries, Inc., of Japan has been a leading manufacturer of PAN based carbon fiber for over 30 years. The Toray Group, including its U.S.-based subsidiary, Toray Carbon Fibers America, Inc., is the world's largest producer of PAN based carbon fibers, with manufacturing and distribution facilities in the United States, Europe, and Japan and a cumulative capacity of 9,100 tons per year. Toray Carbon Fibers America, Inc., began producing carbon fibers in Decatur, AL, in 1999, at a site established expressly for that purpose. The Decatur facility houses a single carbon fiber production line. Toray recently announced a doubling of capacity at the Decatur facility by early 2006. This expansion includes construction of an acrylic white fiber precursor facility, which will provide feedstock to this new production line. In April of 2004, Boeing announced that Toray Industries was selected to provide prepreg composites for use in the primary structural areas of the 7E7 Dreamliner. Toray estimated that each 7E7 will include 30 tons of advanced composite material. The expansion at Decatur is a result of the 7E7 contract.

The establishment of their precursor capability will render Toray DFARS compliant. After completion of the second line in Decatur, the Toray Group's global PAN-based carbon fiber production capacity will reach 10,900 tons per year in 2007. Toray will also increase its PAN carbon fiber capacity in Japan by 2,200 tons, which will bring the Groups global capacity to 13,100 tons by 2007. The carbon fiber produced at the Decatur facility includes standard modulus (33.4 - 34.8 msi), intermediate modulus (42.7 msi), and high modulus (49.8 - 85.3 msi). Toray produces regular and large tow PAN based carbon fibers. The precursor used in the manufacturer of carbon fiber is supplied

from Toray Industries, Japan. The plant is working at 100 percent capacity utilization, and is also expected to remain steady until 2006. Toray Carbon Fibers major customers include Toray Composites America; and an assortment of prepreg manufacturers; weavers/braiders; filament winders; and pressure vessel, automotive marine, and commercial aerospace (including space and satellites) manufacturers. The major end use customers include Boeing Commercial aircraft and Airbus.

The business model of Toray Carbon Fibers America appears to be focused on commercial, non-DoD applications. It is not clear if Toray will compete for DoD business.

#### Toray Industries Financial Assessment

Established in 1926, Toray Industries Inc. (Toray) manufactures synthetic fibers and textiles, chemical products, films, and resins. The company is publicly traded on the Tokyo exchange. Toray Industries has headquarter offices in Tokyo and Osaka, a main office in China, six branch offices, 12 plants, and 12 laboratories and technological development bases in Japan. Its overseas network includes subsidiaries and affiliates in Asia (39), Europe (nine) and the United States (eight). For FY 2004, Toray reported financial results for the following segments: Fibers & Textiles, Plastics & Chemicals, IT-related Products, Housing & Engineering, Pharmaceuticals & Medical Products, and New Products & Other Businesses.

For the fiscal year ended March 31, 2005 (FY 2004), Toray reported sales of \$12.1 billion, operating income of \$755 million, and net income of \$320 million versus FY 2003 sales of \$9.7 billion, operating income of \$504 million, and net income of \$185 million. All segments reported increased sales except the Pharmaceutical & Medical Products segment where sales dropped 7.4 percent; all the segments reported operating profits for the year with margins up at each segment except Pharmaceutical & Medical Products. Fibers & Textiles reported FY 2004 sales of \$4.8 billion and operating income of \$194 million, increases of 21 percent and 13.6 percent respectively over FY 2003 performance. Over 90 percent of total sales and 94 percent of operating income originated in Japan & Asia; sales in North America, Europe & Others represented 9.7 percent of total revenues and accounted for 6.4 percent of operating income.

Table 8 illustrates Toray's segment revenue contributions and operating profit margins for 2003 and 2004.

| <b>TABLE 8: TORAY SEGMENT REVENUE AND OPERATING MARGINS (PERCENTAGE)</b> |                                  |                                     |                                  |                                     |
|--|----------------------------------|-------------------------------------|----------------------------------|-------------------------------------|
| <b>Segment</b>   | <b>2004 Revenue Contribution</b> | <b>2004 Operating Profit Margin</b> | <b>2003 Revenue Contribution</b> | <b>2003 Operating Profit Margin</b> |
| Fibers & Textiles  | 39.5                             | 6.1                                 | 39.0                             | 4.3                                 |
| Plastics & Chemicals   | 23.1                             | 5.2                                 | 23.7                             | 3.8                                 |
| IT-Related Products  | 16.9                             | 12.9                                | 16.0                             | 9.9                                 |
| Housing & Engineering  | 11.5                             | 2.9                                 | 11.0                             | 1.4                                 |
| Pharmaceuticals & Medical Products                                       | 3.4                              | 6.5                                 | 4.4                              | 7.3                                 |
| New Products & Other   | 5.6                              | 12.7                                | 5.8                              | 9.3                                 |

Source: Toray Industries Inc. Press Release dated May 11, 2005: Consolidated Results for the Fiscal Year Ended March 31, 2005

Table 9 illustrates Toray's financial performance.

| <b>TABLE 9: TORAY FINANCIAL PERFORMANCE</b> |             |             |             |
|---|-------------|-------------|-------------|
| <b>Ownership: Toray Industries, Inc.</b>    |             |             |             |
| <b>Financial</b>                            | <b>2004</b> | <b>2003</b> | <b>2002</b> |
| Sales (\$M)                                 | \$12,091    | \$9,656     | \$8,485     |
| Net Income (\$M)                            | \$320       | \$185.5     | \$47.6      |
| Net Margin (%)                              | 2.65%       | 1.92%       | 0.56%       |
| Operating Margin (%)                        | 6.2%        | 5.2%        | 3.2%        |
| Current Ratio                               | 1.23        | 1.16        | 1.08        |
| Debt to Equity (%)                          | 61.6%       | 68.3%       | 79.1%       |
| Cash from Operations (\$M)                  | \$1,113     | \$739       | \$517       |
| Net Cash Flow (\$M)                         | \$217       | \$35        | \$(87.6)    |

Source: Standard & Poor's Compustat Database: Toray Industries Inc. Balance Sheet, Income Statement, and Global Ratio Report.

### **OTHER U.S. LOCATED PAN FIBER PRODUCERS (NON-DFARS COMPLIANT)**

Currently there are four non-DFARS compliant suppliers of PAN carbon fiber in the United States. Table 10 lists them and the locations of precursor and carbon fiber production capabilities. For ease of reference, Table 11 lists the collective capacity of U.S. located non-DFARS compliant suppliers that was listed earlier in Table 2.

Due to the difficulty of obtaining financial information, only Toho Tenax America is discussed.

**TABLE 10: U.S. LOCATED NON-DFARS COMPLIANT PAN CARBON FIBER PRODUCERS**

| Manufacturer              | Zoltek       | Mitsubishi Rayon America (Grafil) | Toho Tenax America (Fortafil Fibers) | Carbon Fiber Technology                                     |
|---------------------------|--------------|-----------------------------------|--------------------------------------|---|
| Ownership                 | Zoltek (USA) | Mitsubishi Rayon Corp (Japan)     | Teijin – Toho Tenax (Japan)          | (50/50 JV) SGL Carbon Group (Germany), Aldila Inc. (U.S.A.) |
| Precursor Location        | Hungary      | Japan                             | Japan                                | Germany   |
| PAN Carbon Fiber Location | Abilene, TX  | Sacramento, CA                    | Rockwood, TN                         | Evanston, WY  |

Source: DCMA Industrial Analysis Center

**TABLE 11: CAPACITY OF OTHER U.S. LOCATED NON-DFARS COMPLIANT PAN CARBON FIBER PRODUCERS**

|                        | FY 2003 | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|------------------------|---------|---------|---------|---------|---------|
| Total Non-DFARS (Tons) | 11,300  | 11,300  | 10,800  | 14,000  | 14,000  |

Sources: (1) DMCA Industrial Analysis Center's analyses of company surveys, press releases and interviews. (2) Composite Manufacturing – January 2005 – "High Performance Materials Expect Strong Year," Bill Benjamin and Chris Red.

### Toho Carbon Fibers

Toho Carbon Fibers, a wholly owned subsidiary of Toho Tenax, acquired the carbon fiber business of Fortafil Fibers, Inc., in August 2004. The facility is located in Rockwood, TN. The carbon fibers business consists of six core products: continuous fibers, prepregs, chopped fibers, oxidized PAN fibers, activated carbon fibers, and composites. The Rockwood facility has three carbon fiber lines producing oxidized PAN fiber, heavy tow chopped fiber, and continuous filament carbon fiber. The carbon fibers produced at the Rockwood facility range from general use (24 msi) to high modulus (35 msi). The precursor used in the manufacturer of carbon fiber is supplied from Toho Tenax, Japan. Toho Carbon Fibers major customers include Cytec Engineered Materials, Hexcel, and Goodrich. The major end use customers include Atlas V, Delta IV, Boeing Commercial aircraft, and business jets for Embraer, Bombardier, and Airbus.

### Toho Tenax Financial Assessment

Toho Tenax Company Limited (Toho), formerly Toho Rayon (name change July 2001), is engaged in the manufacture of textile and related products. The company specializes in the production of materials used in aerospace, aircraft, apparel, sports and recreation, and industrial products. Established in 1934 and headquartered in Tokyo, Japan, Toho is publicly traded on the Tokyo Exchange. Toho Tenax's Carbon Fiber

products business is its largest and fastest growing business; its Textile business produces acrylic and cotton products. The company's other businesses include polyurethane molding machinery and commercial linen supply services. The leading polyester maker, Teijin Limited, has a majority stake (55.2 percent) in Toho Tenax having acquired more than 50 percent of shares in Toho Rayon in February 2000. The company has approximately 1,300 employees.

For the fiscal year ending March 31, 2004, Toho reported sales of \$324.5 million, operating income of \$2.3 million, and a net loss of \$(9.0) million versus FY 2003 sales of \$256.3 million, an operating loss of \$(7.7) million, and net income of \$5.3 million. The carbon fiber segment's sales improved 24 percent in FY 2004 as a result of increased European demand for commercial aircraft and industrial materials. Performance also improved with a return to profitability at Carbon Fiber after four years of operating losses.

Toho Tenax reports financially in four operating segments: Carbon Fiber, Textile, Machinery & Engineering, and Service. Table 12 illustrates Toho's segment revenue contributions and operating profit margins for 2003 and 2004.

| <b>TABLE 12: TOHO SEGMENT REVENUE AND OPERATING MARGINS (PERCENTAGE)</b> |                                  |                                     |                                  |                                     |
|--|----------------------------------|-------------------------------------|----------------------------------|-------------------------------------|
| <b>Segment</b>   | <b>2004 Revenue Contribution</b> | <b>2004 Operating Profit Margin</b> | <b>2003 Revenue Contribution</b> | <b>2003 Operating Profit Margin</b> |
| Carbon Fiber   | 52.5                             | 2.1                                 | 46.6                             | (6.3)                               |
| Textile  | 26.5                             | (5.4)                               | 27.5                             | (4.9)                               |
| Machinery & Equipment  | 15.6                             | 4.7                                 | 19.7                             | 6.1                                 |
| Service  | 5.4                              | 4.6                                 | 6.1                              | 3.6                                 |

Source: Toho Tenax Co. LTD Annual Report 2004, page 19.

Table 13 lists Toho's financial performance.

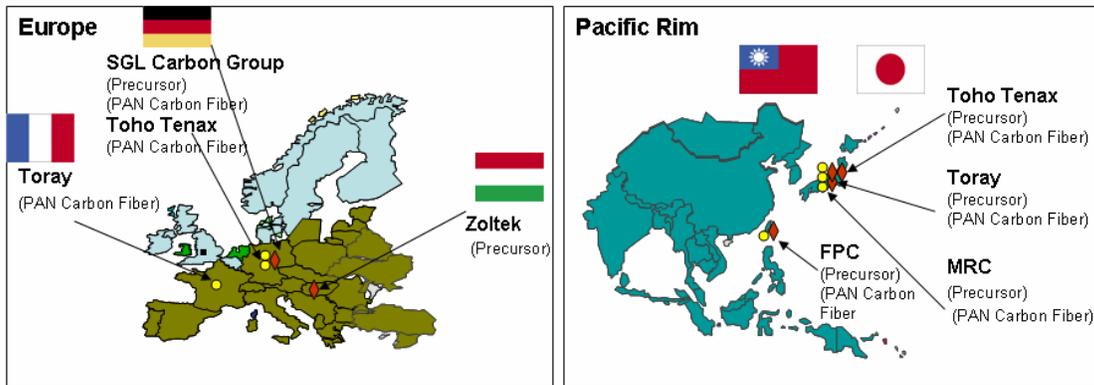
| <b>TABLE 13: TOHO FINANCIAL PERFORMANCE</b> |             |             |             |
|---|-------------|-------------|-------------|
| <b>Ownership: Toho Tenax Company Ltd.</b>   |             |             |             |
| <b>Financial</b>                            | <b>2004</b> | <b>2003</b> | <b>2002</b> |
| Sales (\$M)                                 | \$324.4     | \$256.3     | \$253.7     |
| Net Income (\$M)                            | \$(9.0)     | \$5.3       | \$(11.9)    |
| Net Margin (%)                              | (2.7%)      | 2.1%        | (4.7%)      |
| Operating Margin (%)                        | 0.7%        | (3.0%)      | 4.7%        |
| Current Ratio                               | .81         | .81         | .78         |
| LT Debt to Equity (%)                       | 0           | 0.7%        | 8.8%        |
| Cash from Operations (\$M)                  | \$17.7      | (0.5)       | NA          |
| Net Cash Flow (\$M)                         | \$4.4       | \$(0.9)     | NA          |

Source: Toho Tenax Co. LTD Annual Report 2004, pages 8-12. Standard & Poor's Global Ratio Report, Hoover's, a Dun & Bradstreet Company, and Annual Income Statement.

Four U.S. located manufacturers of PAN carbon fibers procure their precursor from foreign sources. The companies produce only standard modulus carbon fiber (large tow) used in industrial applications. Toho Tenax Rockwood, TN, is converting a percentage of large tow capacity into regular tow capacity used in aerospace applications.

**NON-U.S. LOCATED PAN FIBER PRODUCERS**

Figure 1 summarizes non-U.S. PAN carbon fiber producers and Table 14 summarizes their collective capacity (this data was listed earlier in Table 2, but is repeated here for ease of reference).



**Figure 1: Non-U.S. Located Suppliers**

| <b>TABLE 14: NON-U.S. LOCATED SUPPLIERS NAMEPLATE PRODUCTION CAPACITY</b>   |                |                |                |                |                |
|---|----------------|----------------|----------------|----------------|----------------|
|   | <b>FY 2003</b> | <b>FY 2004</b> | <b>FY 2005</b> | <b>FY 2006</b> | <b>FY 2007</b> |
| Total Rest of World (Tons)  | 18,378         | 18,378         | 20,454         | 22,704         | 24,904         |
| Sources: (1) DMCA Industrial Analysis Center's analyses of company surveys, press releases and interviews. (2) Composite Manufacturing – January 2005 – “High Performance Materials Expect Strong Year,” Bill Benjamin and Chris Red. |                |                |                |                |                |

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## CONCLUSION

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Worldwide demand for PAN carbon fiber has increased and is forecasted to grow six to ten percent per year for the next five years.

In response to growing demand, major PAN carbon fiber producers have expanded or have capital investment plans to expand their precursor and PAN carbon fiber manufacturing capacities. Worldwide nameplate capacity increased by 2.3 percent per year from 2003 to 2005. Worldwide capacity will reach 48,500 tons by 2007, a 41 percent increase from 2003 and a 35 percent growth from 2005.

DFARS compliant suppliers did not add capacity from 2003 to 2005, but will more than double their capacity from 4,650 to 9,550 tons by 2007. DFARS compliant suppliers are expected to produce 19.6 percent of worldwide capacity by 2006. Furthermore, with the addition of U.S. non-DFARS compliant suppliers the U.S.-located suppliers will produce 48.6 percent of the worldwide nameplate capacity.

The outlook for U.S. PAN carbon fiber producers is strong. The two current DFARS compliant producers (Hexcel and Cytec) are qualified suppliers for DoD applications and are operating at very high levels of capacity utilization. Domestic sources have capability and capacity to support DoD requirements, and the addition of Toray Carbon Fibers America in 2006 introduces additional domestic capabilities.

However, no U.S. PAN carbon fibers producers currently are able to manufacture the "high" and "ultra high" modulus fibers likely to be required for future DoD programs.