New composite yarn developed for Slingmax-TPXC Twin-Path Extra slings

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Twin-Path slings impacted the world of the rigging industry several years ago, as they have revolutionized the sling industry. With their light weight, high capacity advantages over other types of slings, they have found their way into every area of lifting in many countries. The innovative design and use of special high density, high strength fibers have played a key role in furthering the advancement of large and difficult lifts found in every type of industry. But today, another giant leap is evident in the new and improved Twin-Path Extra Sling with Covermax (TPXC), available through Slingmax.

The use of synthetic fibers and materials in the fabrication of slings began in the 1930's with the development of the nylons, polyesters, polyethylenes and polypropylenes. The nylons and polyesters have found great usage in manufacturing of synthetic flat bodied and round-bodied slings, particularly since the 1970's. In fact, the first Twin-Path slings, patented in 1989, incorporated the use of polyester as load bearing filaments as well as the outer tubular coverings.

In the 1960's, Kevlar, a dramatically new, high strength material from Dupont, made great inroads into many

Photo #1

markets, including that of sling fabrication. This unusually strong fabric was meeting equivalent tensile strengths of steel, while weighing only about 10% as much. After several years of using Kevlar in round bodied slings, other hybrids of high strength fibers were being developed and introduced, such as Technora, Spectra, Vectran and Twaron from manufacturers around the world. Each of these fibers are significantly greater in strength than previously known synthetics, yet each has its own specific properties and characteristics. So with the development of these high strength synthetic fibers, the Twin-Path slings took a new direction – that is, Kevlar was first introduced as the new load-bearing elements within the Twin-Path sling design, with use of some of these other high density filaments to follow.

But development and curiosity did not lie dormant at Slingmax. Following thousands of hours of testing and development, plus field performance evaluations, Slingmax developed its own optimum high strength fiber combinations for use in the fabrication of the Twin- Path slings. This new yarn is a composite known as K-Spec, which is a combination of Technora and Spectra fibers. These combined fibers (Photos #1 & #2) provides extremely high strength and low elongation along with superior resistance to abrasion, fatigue and chemical attack. These combined fibers are wound into strands which then form the load bearing elements of the TPXC slings. Continuous testing and evaluation has also enlightened sling manufacturers and

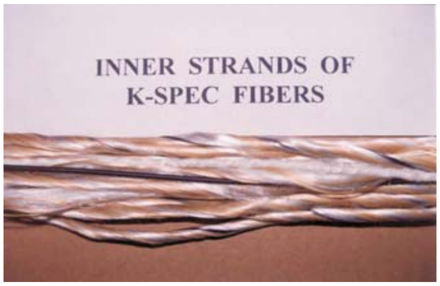


Photo #2

EXHIBIT #1

TWIN-PATH® EXTRA COVERMAX SPECIFICATIONS

United States Patent #4,850,629 — Rated Capacities (Lbs.) 5-1 D/F — Canadian Patent #1,280,458

Twin-Path® Extra Covermax Stock No.	Choker	Vertical	Basket Hitches 0°	Basket Hitches 60°	Basket Hitches 45°	Approximate Weight (Lbs. per FL) (Bearing-Bearing)	Approximate Body Width (Inches)
TPXC 1000	8,000	10,000	20,000	17,320	14,140	.31	3"
TPXC 1500	12,000	15,000	30,000	25,980	21,210	.40	3"
TPXC 2000	16,000	20,000	40,000	34,640	28,280	.55	3"
TPXC 2500	20,000	25,000	50,000	43,300	35,350	.65	4"
TPXC 3000	24,000	30,000	60,000	51,960	42,420	.80	4"
TPXC 4000	32,000	40,000	80,000	69,280	56,560	1.12	5"
TPXC 5000	40,000	50,000	100,000	86,139	70,700	1.50	5"
TPXC 6000	48,000	60,000	120,000	103,920	84,840	1.60	5"
TPXC 7000	56,000	70,000	140,000	121,240	98,980	1.68	6"
TPXC 8500	68,000	85,000	170,000	147,220	120,190	1.85	6"
TPXC 10000	80,000	100,000	200,000	173,200	141,400	2.20	6"
TPXC 12500	100,000	125,000	250,000	216,500	176,750	3.00	8"
TPXC 15000	120,000	150,000	300,000	259,800	212,100	3.36	8"
TPXC 17500	140,000	175,000	350,000	303,100	247,450	4.00	10"
TPXC 20000	160,000	200,000	400,000	346,400	282,800	4.37	10"
TPXC 25000	200,000	250,000	500,000	433,000	353,500	5.50	11"
TPXC 27500	220,000	275,000	550,000	476,300	388,850	6.90	11"
TPXC 30000	240,000	300,000	600,000	519,600	424,200	7.50	12"

PLEASE NOTE: Capacities shown include both paths and are for one complete sling. Ratings based on diameter one-half the sling width.

DO NOT EXCEED RATED CAPACITY **DO NOT EXCEED RATED CAPACITY**

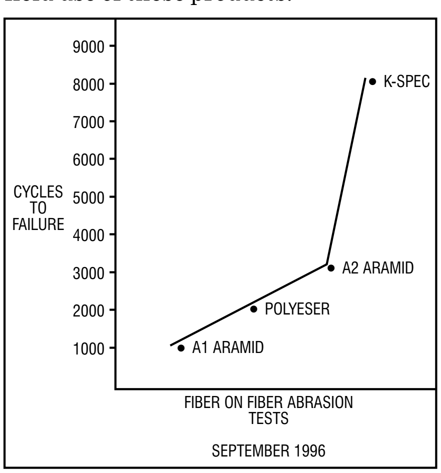
users to additional benefits, such as light weight per loading capacity; cost efficiency and minimum creep under load.

EXHIBIT #2

FIBER ON FIBER ABRASION TESTING SEPTEMBER 14th, 1996

These tests were to determine the difference between K-Spec core yarn and polyester core yarn as used in SLINGMAX® rigging products.

The yarns were each weighted to 2.7% of their breaking strength. They were water and air cooled so that there would be no deterioration caused by heat. The polyester has a breaking strength of 600 lbs. in a sling and was weighted to 16 lbs. The K-Spec was weighted to 48 lbs. The test consisted of raising and lowering this load through a 2" arc consisting of a loop of the same material. This is a very severe test and it is highly unlikely that similar conditions would ever be present in the field use of these products.



The extra high strength achieved from the K-Spec fabric in conjunction with Covermax tubing is reflected in the catalog rated capacity chart (Exhibit # 1). The Technora is a para-aramid fiber developed by Teijin and has 7 times the strength of steel per unit weight. The Spectra is a high density polymer manufactured by Allied Signal and has 10 times the strength of steel per unit weight. Technora has excellent abrasion and bending fatigue resistance as compared to other high strength fibers. For example, abrasion of the Technora fibers when tested against itself lasted almost three times as long before failing as did other high strength fibers tested in an identical manner. The composite K-Spec fibers perform even better than Technora, outlasting it by 3 to 1 (Exhibit #2). In bending fatigue, the Technora retained 52% of its original strength after 2000 cycles, as compared to only 36% strength of other high strength fibers (Exhibit #3). When Technora is combined with Spectra, the resultant is K-Spec, which has similar results in bending fatigue as noted for Technora. Twin-Path slings made with K-Spec outperform previously manufactured Twin-Path slings with Kevlar; and compared to wire rope slings, Twin-Path slings with K-Spec far outdistance wire rope slings in cyclical loading tests (Exhibit #4).

The abrasion resistance of the K-Spec yarns is also far superior to the previously used polyester fibers. This fact has been established by laboratory testing and by performance evaluation in actual lifting conditions. Tests consisting of abrading one strand of fibers perpendicularly against a second strand of the same type of fibers were conducted. The abrasion cycles continued until at least one strand failed. The load used to compress these strands was based upon about 3% of the known breaking strength of the fiber strand. The polyester strands failed after 1,574 cycles, while the K-Spec fibers, tested under identical conditions, failed after 8,672 cycles.

Technora fibers also perform much better at elevated temperatures than other high strength fibers, as well as nylon and polyester. Although the recommended maximum temperature of 180 degrees Fahrenheit is listed in catalogs and applicable standards, testing by Teijin shows Technora still retains up to 80% of its strength when held at 482 degrees Fahrenheit (Exhibit #5). Chemical exposure tests of Spectra and Technora reveal excellent resistance to deterioration by acids, alkalis and salt water (Exhibit #6, #7 & #8). Therefore, the composite K-Spec material has superior resistance to chemicals, and when exposed to such conditions such as salt water, acids, alkalis and organic solvents for six months, it still retained 100% of its original strength.

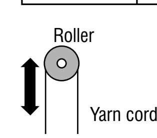
An extra value of TPXC slings which is oftentimes overlooked is the Covermax outer covering. Slingmax has spent considerable time and energy in working with suppliers to develop the optimum covering providing strength and flexibility, while providing resistance to abrasion, cutting and chemical attacks. The Covermax tubing is a bulked nylon construction which provides these features along with reduced stretching under load. Photograph #3 shows a cutaway of both Covermax coverings over the inner load bearing K-Spec fibers. Field results from actual usage show that the

EXHIBIT #3

Characteristics of Technora®

Fatigue resistence
(2) Bending fatigue resistence

	Retension of tensile strength
Technora®	52%
PPTA	36%



Sample cord : 1670T/1X2
Bending conditions :
Roller diameter 10mm Φ
D/d 15
Load 1.8kg
Number of cycles 2,000

EXHIBIT #4

FATIGUE TEST SUMMARY
OCTOBER 1997

Product Description	Actual Breaking Strength	Tension Member	Test Load	% of Ultimate	# of Cycles	Retained Strength	Pin Size	Breaking Strength as a % of Catalog Strength
Flemish Eye 6 x 25 IWRC EIP Wire Rope Sling Steel Sleeves	68,000	Wire Rope	20,000	29%	29,407	0	2"	0%
TPXC 1,000 x 11' Twin-Path® Extra	60,300	Kevlar® 3 Strand	20,000	33%	55,148	0	2"	0%
K-2,000 x 6' Single-Path	100,000	Kevlar Single-Strand Twisted	30,000	30%	50,000	86,500	2"	86.5%
TPXC 2,000 x 6' Twin-Path® Extra	100,000	K-Spec	30,000	30%	50,000	105,500	2"	105%

Note: 1. Clearly the K-Spec gives the best results
2. Wire Rope suffers from severe fatigue
3. 3 Strand Kevlar® suffers from yarn on yarn abrasion
4. Single strand twisted Kevlar® shows less abrasion but is rapidly declining in ultimate strength.

The TPXC with K-Spec is the only sling in the world that does not lose strength as a result of use.

Photo #5

Photo #6

Photo #7

Photo #3

Photo #4

Covermax tubing has enhanced longevity of the TPXC slings. One outstanding example is that of the slings used in a Toyota factory, where TPXC slings made more than 30,000 lifts without rupturing of the Covermax tubing.

Additionally, Covermax is much more resilient and resistant to cutting than other types of sling covers. Laboratory tests using repetitive cutting motions have shown that Covermax is many times more difficult to severe than conventional nylon or polyester coverings. A knife edge with a cutting pressure of 10 pounds was repeatedly run across the same location of both a Covermax jacket and a comparative polyester jacket. After 10 repetitions of cutting, the polyester material had been cut to where the load bearing yarns are exposed (Photo #4). The Covermax material shows only a few of the outer fibers snagged after 10 cutting cycles but none were cut (Photo #5). After 46 repetitions of cutting cycles, the Covermax fibers begin to be cut (Photo #6); and after 56 cycles of cutting, the internal load bearing K-Spec fibers are exposed (Photo #7).

EXHIBIT #5

Characteristics of Technora®

Graph 11 Heat resistance of Technora® for long periods

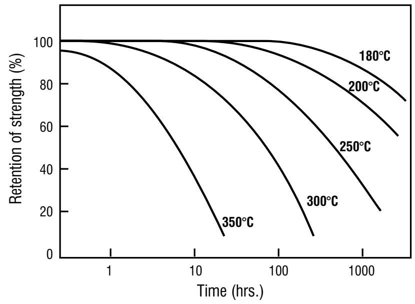


EXHIBIT #6

Strength Retention After Chemical Immersion
(% Retention)

	Spectra Fiber	
Agent	**6 Months**	**2 Years**
Sea Water	100	100
Hydraulic Fluid	100	100
Kerosene	100	100
Gasoline	100	100
Toluene	100	96
Glacial Acetic Acid	100	100
1M Hydrochloric Acid	100	100
5M Sodium Hydroxide	100	100
Ammonium Hydroxide (29%)	100	100
Perchloroethylene	100	100
10% Detergent Solution	100	100
Clorox	91	73

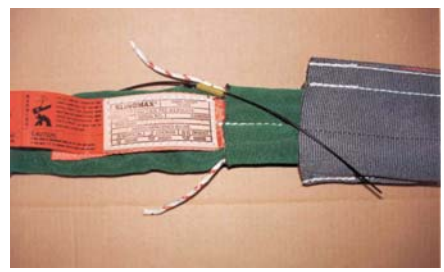
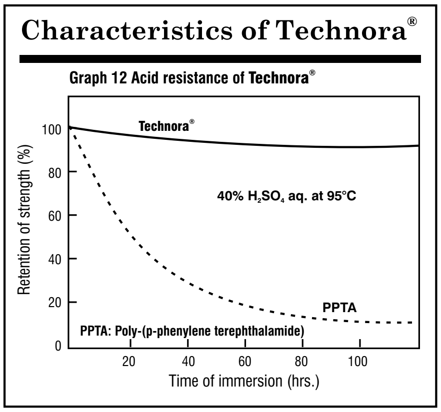


Photo #8

The superior characteristics of TPXC slings have been proven by hundreds of tests and ongoing research and development. But how do the overall physical properties of TPXC slings compare to the competitive slings in the marketplace? First, by comparing the properties of TPXC slings to other types of slings available, the advantages of TPXC slings immediately becomes obvious. Exhibit #9 shows that TPXC slings have the lowest weight/strength ratio of all known slings, providing a significant advantage in handling and reduced rigging time. Exhibit #10 graphically displays the comparable stretch characteristics of TPXC slings to those fabricated from wire rope, chain and nylon. TPXC slings will stretch about 1% at rated capacity, and exhibit approximately 3% elongation at ultimate breaking strength. Wire rope stretches about this same 1% at rated capacity, while

EXHIBIT #7



displaying about 4%-5% elongation at ultimate breaking strength. So the behavior of TPXC slings is very comparable to wire rope slings under load. However, synthetic web and round bodied slings behave much differently. Nylon web slings stretch approximately 6% and polyester web slings stretch about 3% at rated capacity. Polyester round bodied slings will stretch this same 3%, unless the polyester is braided into a multi-part sling, where elongation at rated capacity can reach 9%. This TPXC property of minimum stretch under load provides better load control; permits minimum overhead clearances; and allows more predictability in determining resultant sling angles during lifting.

The advantages of high strength and light weight are dramatic in reducing the time involved in rigging and handling, thus leading to reduced overall labor costs. Slings can be installed in less time and with fewer personnel, and inspection time is greatly reduced due to ease of handling. Proprietary inspection techniques of Slingmax TPXC slings is an added assurance of complete inspection in a minimum amount of time.

TPXC slings play a major role in enhancing rigging safety. A notable example where safety is of primary concern is that of attaching slings from a crane hook to a load at elevated heights where handling techniques and personnel are limited. A load requiring a 500 pound wire rope sling to be attached can be dangerous, time consuming and may be impossible at these heights. This same load can be lifted with a TPXC sling weighing about 100 pounds. This weight reduction is not only significant in the areas of safety and cost reduction in man-hours, but TPXC slings allow greater loads to be lifted with the crane by reducing the weight of the rigging below the hook.

Another intangible advantage of TPXC slings is their cleanliness, particularly when compared to wire rope slings. This is not only a personal hygiene matter, it can be an environ-

EXHIBIT #8

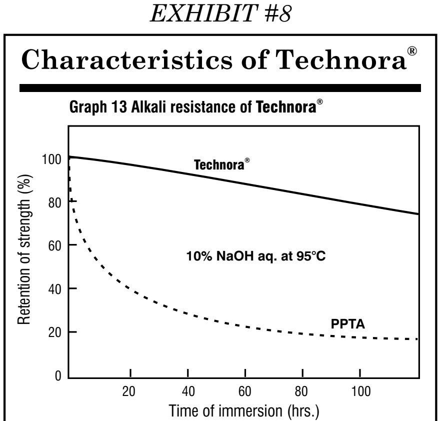


EXHIBIT #9

COMPARISON OF INDUSTRY SLINGS

Sling Type	Size	Rat. Cap. (lbs.)	Wt/Ft. (lbs.)	% Elon. @ Rat. Cap.	Max. Temp. (F.)
Twin-Path Extra	TPXC 6000	60,000	1.6	1.0	180
Kevflex (Kevlar)	Ken 800	66,000	1.9	1.0	250
Nylon Web	3, 4-Ply, 4"	54,600	4.0	8.0	194
Round-Bodied (Poly)	EN 800	66,100	3.0	6.0	194
Wire Rope	1/7/8", EIP	64,000	6.5 + Eyes	1.0	400
Chain (Grade 100)	1"	59,700	10.7	0.5	600

EXHIBIT #10

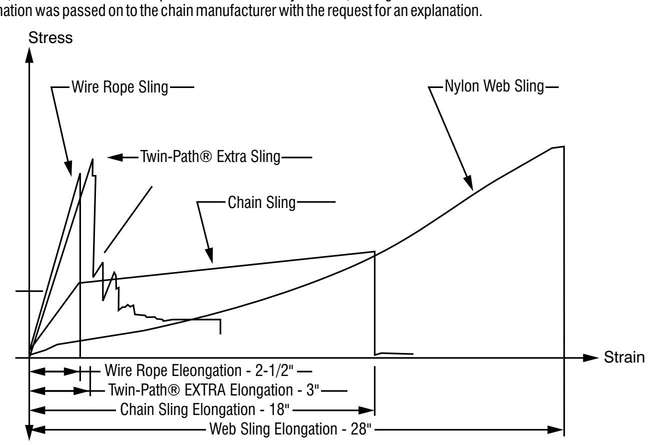
Destruction test results of various Lifting Slings

JULY 31, 1996

Scope: To demonstrate the difference in elongation and the types of failures.
Slings used: (All slings having a length of 12 ft)

	Type	WLL (DF 5:1)	MBS	Breaking Strength
1)	1-1/8" diameter wire rope sling, 6x36 IWRC, IPS, RRL	22,000 lbs	110,000 lbs	114,390 lbs
2)	TWIN-PATH® EXTRA sling, Type TPXC 2000	20,000 lbs	100,000 lbs	124,540 lbs
3)	UNI-WEB™ Nylon Web Sling Type EE2-908-3	22,700 lbs	113,500 lbs	129,970 lbs
4)	5/8" Alloy Chain Sling with Coupling Links and Master Links	18,100 lbs (l)	72,400 lbs	67,240 lbs

Note: 1) WLL based on DF 4:1 only. Sling broke premature due a link failure. Elongation recorded is lower than normally expected. A second test on August 1, 1996 in which the ram speed was considerably LOWER, a sling made from the same batch of chain broke at 73,980 lbs. This information was passed on to the chain manufacturer with the request for an explanation.



mental concern. The lubricants applied to the wire rope for lubricity and corrosion protection can sometimes be harmful to the environment. So with TPXC slings, both the hygiene and environmental problems are eliminated.

Other significant advantages of the TPXC slings are ease and completeness of inspection. With the increase in weights of loads being lifted and number of lifts being made, safety is a major player in determining the type of sling to use. ASME B 30.9 and applicable OSHA regulations lists procedures to follow when inspecting various types of slings. All of these inspection standards have been established by thousands of tests, research, and comprehensive evaluation. However, TPXC slings takes inspection to a higher level. TPXC slings not only incorporate the normal inspection criteria, but add the extra precautionary patented "tell-tails" and "fiber optics" technologies (Photos #8). These easy to use inspection techniques can be quickly accomplished and provide additional assurance that the sling has been thoroughly inspected.

The tell tails, one in each independent sling path, indicate if a sling has been overloaded. These exposed tails of internal fibers are preset to an exposed length, and if they are found to be shorter after use, or have pulled back into the body of the sling, this is an indication of overload. The fiber optic cables will transmit light throughout the entire length of the sling if no damage has occurred. However, the transmission of light will be terminated if the sling has experienced significant crushing, heat damage, chemical attack or cutting of the load bearing fibers. Both of these additional inspection features benefit the end user in helping to prevent accidents.

The advantages that TPXC slings have over wire rope, chain and other lower strength synthetics may now seem fairly obvious. But how do these TPXC compare to round bodied slings using other high strength synthetic fibers? Comparison of these slings reveal several important facts as noted below:

(1) The twin-body configuration, using an identical number of fibers, and compared to a single body design, provides higher strength. Recent test results state:

"A single Path round sling and a Twin Path sling were fabricated with the same number of core yarn strands, and each sling had 25% of the core yarns cut. The material used for tension members in both slings was K-Spec fiber. The calculated breaking strength of each sling with no cut strands was 125,000 pounds. The Single Path sling was pulled to ultimate breaking strength, and ruptured at 65,400# (52% of calculated strength). The Twin Path sling pulled in two at 114,100# (91% of calculated strength)."

This dramatic difference makes it quite clear that the efficiency of a Twin-Path sling is far superior to a Single Path configuration. The twin path design provides higher strength efficiency by allowing the fibers to more equally carry a proportionate share of the total load by dispersing the fibers to locations closer to the bearing surfaces. In a single path sling, the outer fibers are distanced further from the load bearing area, thus causing more disparity among the load bearing fibers.

(2) As discussed, Twin-Path slings provide additional inspection techniques which provide safer lifting practices and makes the user more knowledgeable of the sling conditions. Round bodied slings have no "tell tails" to indicate overloading and no "fiber optic cables" to indicate internal damage.

(3) The new outer Covermax covering of Twin-Path slings provides superior wearing properties and enhanced resistance to cutting, abrasion and chemical attack over the covers of competitors' round bodied slings.

(4) The K-Spec filaments of the Twin-Path slings provides much less stretch than polyester filaments of some round bodied slings. Twin-Bodied slings stretch approximately 1% at rated capacity, whereas polyester slings stretch 3%, and braided polyester slings stretch up to 9%.

(5) The manufactured length tolerances of Twin-Path slings are easily held to a maximum of +/- ½", which is far superior to the round bodied construction, where length tolerances, at best, are +/- 1", but mostly much greater. Braided polyester, round bodied slings list length tolerances of +/- 5%. There is no dispute regarding the superiority of Slingmax Twin-Path slings when it comes to meeting close tolerances.

(6) Round bodied slings using Kevlar as the load carrying fibers are limited to the number of lifts they can make, based upon industry testing. Manufacturers limit the lift cycles to 500 because of concerns over fatigue and internal wear. TPXC slings have no limitation on number of lifts since testing shows no degradation after thousands of lifts.

(7) Twin-Path slings provide redundant back-up protection by having two independent connections between the hook and the load, whereas single path slings have no backup. This redundancy of Twin-Path design allows holding of the load at high design factors under the condition of having one path cut.....not the case with single bodied slings.

(8) Round bodied polyester slings weigh about 2.3 times that of Twin-Path slings for equivalent lifting capacities. This is quite a savings in time to rig and offers much easier handling with fewer personnel.

The advantages of TPXC slings are very clear and have been proven by testing and performance. Like all slings, precautionary measures must be taken and correct usage practices must be followed. The instructions and warnings on the use of these slings, as listed on the sling tags and in the brochures, must be read, understood and followed. Always inspect slings before each use in accordance with ASME B 30.9 standards. Notably, inspection is faster and more complete with TPXC slings than with any other type of sling.

Because one of the primary causes of synthetic sling failures is cutting or abrasion, it is recommended that corner protectors or "softeners" be used if the slings are to be exposed to sharp edges, small bend radii or rough surfaces. Under heavy loading conditions, a metal/manufactured rated protector or equivalent should be used. An additional product from the Slingmax group is a patented corner protector specifically designed for synthetic slings. This product has proven its worth in handling heavy loads with small radii corners without any evidence of cutting, abrasion or other type of damage.

Overall, Slingmax offers the most advanced and safest slings available today. With the availability of TPXC slings, no other sling offers the high strength, low weight capabilities; long service life; and enhanced resistance to chemical attacks, cutting and abrasion. The TPXC slings are the "high tech" slings available today and are quickly proving to be the slings of choice. ☐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