

Glider Tow Ropes

WWII Military Gliders

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World War II training, experimental and combat gliders were towed behind a variety of US Army Air Force aircraft by tow ropes of various lengths and diameter. Those tow ropes were made of nylon, a relatively new synthetic fiber. It was best known before the war for its use in the manufacture of ladies' hosiery. The Waco CG-4A, cargo and troop carrying glider, the mainstay of the USAAF combat glider fleet, was towed with a 350 foot long nylon tow rope that was $11/16^{\text{th}}$ of an inch in diameter. Nylon rope would stretch approximately 25% of its length under tension without breaking, yet contracted slowly when tension was reduced, thereby absorbing much of the initial shock when the glider was towed down the runway for takeoff and while in flight. The smaller two and three passenger training gliders used a $1/4$ inch tow rope that was 300 feet in length, while the 30 and 42-passenger Waco CG-13A was towed with a 350 foot tow rope, $15/16^{\text{th}}$ of an inch diameter.

Nylon had all the characteristics required for a glider tow rope, strength, durability, and elasticity, and it was also mildew resistant. The only drawback was that the ultraviolet rays of the sun were damaging to nylon threads. When not in use, the tow ropes were stowed on reels away from the sunlight, and in the coolest and driest place possible. The AAF engineers at Wright Field determined that the advantages offered by nylon far outweighed the disadvantages of its high cost and short service life. A single tow rope, 350 feet in length, and $11/16^{\text{th}}$ of an inch in diameter, cost \$525.00 (\$1.50 per linear foot).

Military researchers were aware of DuPont's miracle nylon fiber long before it was announced at the 1939 New York World's Fair, but envisioned its use only as a substitute for silk in the manufacturer of parachutes. With tension between the United States and Japan on the rise in 1938 and 1939 it was essential that a suitable substitute be found since a majority of silk came from Japan. The use of nylon for glider tow ropes was still in the future, but so that readers may better understand how nylon became the fiber of choice for glider tow ropes, a brief summary of its discovery, use and characteristics follows.

The process of making nylon fiber was developed in 1935 by E. I. DuPont de Nemours, a chemical company in Delaware, but was not announced to the public until 1938. It appeared at the New York World's Fair in the form of ladies hosiery, and immediately became a hit with women because of the sheerness and elasticity of the fabric. Over 500,000 pairs were sold at the fair. The fiber was still so new in 1939 that DuPont's first nylon plant at Seaford was not yet completed. The fiber for the ladies hosiery sold at the fair was produced by the company's experimental station in Wilmington. Readers

are reminded that DuPont made only the fiber, not the hosiery material itself. The fiber was sold to textile producers who sold the hosiery material to end-product manufacturers.

Shortly after the World's Fair the U.S. Army Air Force at Wright Field, near Dayton, Ohio, ordered some nylon fiber for testing by the Materials Laboratory of the Engineering Section. It soon found that it would not only serve as an acceptable substitute for silk but had several characteristics which made it superior to the best grade of silk. The Equipment Laboratory at Wright Field reported in June 1940 that tests conducted with standard-type parachutes constructed of nylon showed that they compared favorably with those made of silk.

Nylon fabric was produced in various deniers, a fiber size defined in grams per meter. To compete with silk, which was 30 denier, nylon was drawn to a lighter and finer 15 denier. A fiber 9,000 meters long weighing 15 grams was 15 denier. It was the finest material, and 105 denier was the heaviest material made World War II. The DuPont Company was the only producer of nylon at that time. A majority of WWII parachutes and all the glider tow ropes were made of nylon.

During the Second World War the British used hemp rope to tow their Horsa and Hamilcar combat gliders, while the United States used nylon exclusively. The production of hemp rope had been greatly curtailed by law in America. During the late 1930s there was a huge movement to ban marijuana. The movement began as a ban on the use of marijuana, but the entire hemp plant was added as more people and companies lent their financial and moral support to the ban. The DuPont Company was a major financial contributor to the movement. The ban on hemp was no great loss, since nylon was far superior for glider tow ropes.

On 13 December 1943, the Army Air Force issued Technical Order Technical Order No. 09-1-13 titled "General – Handling and Repair of Glider Towline Assembly." It would become the Bible of glider tow ropes. Some of its provisions are shown below:

A. Dimensions and Length of the Tow Rope for Various USAAF Gliders

<u>Glider Type</u>	<u>Part No.</u>	<u>Stock No.</u>	<u>Diameter</u>	<u>Length</u>
2-Place Glider	43A15088	4500-538642	1/4 inch	10 ft.
2-Place Glider	43A15008-3	4500-538645	1/4 inch	300 ft.
2-Place Glider	43A15008-1	4500-538646	1/4 inch	360 ft.
2-Place Glider	43A55D88-2	4500-538648	1/4 inch	420 ft.
9-Place Glider	43A15089	4500-538635	1/2 inch	15 ft.
9-Place Glider	43A15089-2	4500-538637	1/2 inch	75 ft.
9-Place Glider	43A15089-1	4500-538638	1/2 inch	350 ft.

<u>Glider Type</u>	<u>Part No.</u>	<u>Stock No.</u>	<u>Diameter</u>	<u>Length</u>
15-Place Glider	43A15090	4500-538600	11/16 in.	15 ft.
15-Place Glider	43A15090-2	4500-538625	11/16 in.	75 ft.
15-Place Glider	43A15090-1	4500-538630	11/16 in.	350 ft.
30-Place Glider	44A8009	4500-538641	15/16 in.	350 ft.

Note: The three lengths of tow rope for 2-place gliders are for triple tows. For double tows of the 15-place glider the 75 foot length of tow rope is attached to the 350 foot tow rope with a metal swing link and connector link. 2-place lines are 1/4 inch; 9 place lines are 1/2 inch; 15 place lines are 11/16 inch; and 30 place lines are 15/16 inch.

B. Tow Rope Assembly

(1) Tow rope assemblies will be assembled in accordance with the proper drawing for the glider being towed as indicated below:

- a. Drawing No. 43-D536 Tow Rope Assembly - 15-place glider
- b. Drawing No. 44-D192 Tow Rope Assembly - 30-place glider
- c. Drawing No. 43-D537 Tow Rope Assembly - 9-place glider
- d. Drawing No. 43-D538 Tow Rope Assembly - 2-place glider

C. Laying out Tow Ropes

(1) In laying out tow rope assemblies before flight a truck will be used. The rope will be laid out by moving the truck forward not by pulling the rope backward off a reel with the truck stationary.

(2) As the tow rope is laid out it will be checked by a responsible member of the ground crew through its entire length for cuts, abrasions, and damaged hardware.

D. Tow Rope Attachment to Tow Plane

(1) When attaching a tow rope to a tow plane, a member of the ground crew will stand in front and to the left of the tow plane in full view of the pilot. He will relay to the pilot the signals of the hook-up man at the tail of the tow plane. The signals for "Open Release," shall be an open hand with spread fingers. The signal for "Close Release" shall be a clenched fist. Adequate signals for night operations will be used in accordance with the nature of the flight.

(2) The action of the tow plane release system will be tested at least once before each flight. This will be done by the hook-up man first attaching the tow rope to the release, then pulling on the tow rope until the pilot pulls the release handle. During this test the hook-up man will grasp the tow rope close enough to the end fitting to prevent it from hitting the

ground upon release. This will prevent damage to the plug from striking the runway or becoming clogged with mud or dirt. If the release works satisfactorily, it will be reattached for take-off.

(3) It will be the responsibility of the hook-up man to check the position of the visual indicator pin on all tow plane releases after the plug has been inserted. No hook-up will be considered complete, nor will any flight be allowed to proceed, until the indicator pin is flush with its housing.

Note: To facilitate the visual inspection of the position of the indicator pin, the indicator pin housing will be painted black and the end of the indicator pin will be painted white. This can be accomplished by opening the release and while the indicator pin is depressed, paint the housing black. Close the release bringing the indicator pin into flush position. Place a small drop of white paint on the top of the indicator pin.

(4) Replace any plug that does not seat properly with a slight movement (freeness) in the release jaws.

E. Tow Rope Attachment to Glider

(1) When attaching the tow rope to the glider release, the hook-up man will give his instructions to the pilot by a signal or by voice. The tow rope will never be attached to the glider unless the pilot is in his seat ready to fly.

(2) The glider release system will be tested at least once before every flight. This will be done by the hook-up man attaching the tow rope to the release handle. During this test the hook-up man will grasp the tow rope close enough to the end fitting to prevent it from hitting the ground upon release. This will prevent damage to the plug from striking the runway or becoming clogged with mud or dirt. If the release works satisfactorily, it will be reattached for take-off.

(3) In case of the plug type release, it will be the responsibility of the pilot to personally check that the visual indicator pin is flush with its housing after the plug is inserted. In the case of the hook and ring type release, it will be the responsibility of the pilot to have the tow rope hook-up man check the security of the hook-up.

(4) No glider pilot will ever leave his seat before take-off without first insuring that the tow rope is not attached to his glider.

F. Tow Plane/Glider Take-Off Procedure

(1) After the tow rope has been attached first to the tow plane and then to the glider, the glider pilot will direct the tow plane pilot by radio or telephone in the final preparation for takeoff:

- a. Slack will be completely removed from the tow rope.
- b. The glider pilot will give the tow plane pilot final notification of his preparedness for takeoff.

G. Release of Tow Rope from Glider

(1) When the glider releases, the following conditions will prevail:

- a. Plenty of slack in tow rope.
- b. Speed as slow as practicable with the particular tow plane glider combination

being used.

Note: After the release of the glider, the tow plane should be operated at its approximately minimum safe flying speed, until the rope is dropped. This will reduce the whipping of the free end of the tow rope and prolong its life. This applies to training flights only.

H. Release of Tow Rope from Tow Plane

(1) Two- and three-place tow ropes will be dropped from 300 feet altitude. Nine-, fifteen-, and thirty-place tow ropes will be dropped from 500 feet altitude.

(2) Tow ropes will be dropped on sod wherever possible. They will never be dropped on runways, on rocky surfaces, nor will the tow plane ever land with the tow rope attached. In any of the above cases, this procedure always results in the ruin of fittings and probable ruin of the rope. At best, the life of the rope is reduced to a low fraction of what it would be with proper treatment.

I. Inspection and Repair of Tow Rope

(1) In addition to the preflight inspection directed above, the tow rope will be inspected at 10-flight intervals by an engineering officer. The tow rope will be wound from one reel to another and examined with special care for evidence of "stickiness" between strands indicating fusion. Each glider activity not now provided with a two reel assembly, Part No. 43D2241, Stock No. 8200-809000, will requisition same from AF Stock for this inspection.

(2) Tow ropes will be inspected for the following defects which may cause failures: (See illustrations, figures 1 to 8 inclusive in T. O. 09-1-13, dated 13 December 1943)

Loose or frayed splices

Cuts and abrasions

Backturns

Burns

Broken strands

Fusion

Defective hardware

Figures 1 and 2

Figures 3 and 4

Figure 5

Figure 6

Figure 7

Figure 8

Note: Loose and frayed splices will be properly reworked. A four-tuck eye splice (figure 9) will be used at the end of the rope when splicing the thimble. Tow rope cuts and abrasions, when the damage is local, may be repaired by splicing in a new section to one section of the rope.

A 12-tuck splice may be used. (See figure 10.) Tow ropes with cuts and abrasions throughout their whole length and numerous cuts or broken strands will not be repaired.

(3) Twelve-tuck short splices will be used to repair tow ropes which have been cut to remove damaged sections.

J. Backturns or Hockle

(1) Unlaying of strands of rope produce excessive localized stress due to the sharp bending of strands.

(2) Repair by cutting through center of backturn and splicing as described in H(3).

K. Burns

(1) Nylon ropes, when dragged over a hard or rough surface, "burn" from the heat generated. Flat, smooth surfaces on the rope are the first indication of this failure. The small strands of nylon are fused together and become brittle and the rope loses its strength characteristics. Short sections of burned rope may be cut out and the rope repaired by splicing in a section.

L. Fusion

(1) In addition to "burn," nylon rope has a tendency to fuse from sudden release of excessive stress or twisting, and loss of strength as a rope results. Indications of fusion are a slight stiffness in the rope compared with its usual pliability. This stiffness may be of short length and should be watched for when unreeling a tow rope before flight. Give a very close examination, if suspected. Tow ropes with evidence of fusion may be repaired by splicing in a new section only with the approval of the engineering officer.

M. Tow Rope Hardware

(1) Defective hardware, particularly plugs and thimbles, will be replaced with new parts. Plugs which do not fit properly are considered defective and will not be used under any circumstances. Thimbles will be replaced if dented or damaged in the dropping of the tow rope so that the rope does not have free play through its thimbles.

(2) Thimbles without flared flange will be flared to avoid cutting ropes. Thimbles will not be fitted in release plugs, Part No. 42D8750.

(3) Minimum length of towline after repair is 325 feet.

N. Towlines will be condemned when:

(1) A strand is found broken from stress. This does not include broken fibers indicated by a fuzziness caused by abrasion or cuts.

- (2) Backturns - Rope repaired one time for this cause will be condemned on second occurrence.
- (3) When burns are found through entire length of rope.
- (4) When fusion is evidenced by stickiness of strands.
- (5) All condemned nylon rope will be properly tagged and forwarded to the salvage officer of the control Air Service Command for reclamation. Hardware condemned will be properly tagged and disposed of in accordance with AAF Regulation 65-43.
- (6) Plugs will be condemned when facing plate a/w T. O. No. 09-1-12, fails to give a perfect fit.
- (7) Thimbles will be condemned when dented to prevent free movement of the rope within them.
- (8) Other hardware will be condemned by the engineering officer when nicks or breaks may impair its strength.

O. Parts Requisitioning

(1) The following parts will be requisitioned as needed to comply with the provisions of T. O. 09-1-13:

<u>Stock No.</u>	<u>Part No.</u>	<u>Nomenclature</u>	<u>Class</u>	<u>Source</u>
8200-856000	42D264	Spool Assembly -Glider tow rope storage	19-A	AF Stock
8200-809000	43D2241	Reel Assembly - Spool, handle, support	19-A	AF Stock
4500-677300	42D8750	Plug assembly - Aerial towing release	03-F	AF Stock
4500-904750	42B9487	Thimble - 15-place glider tow rope	03-F	AF Stock
4500-539000	43D1644	Link Assembly, Glider tow rope swing	03-F	AF Stock
4500-540600	43A299	Link - 15-place glider tow rope	03-F	AF Stock
4500-904775	42B9486	Thimble - 9-place glider tow rope	03-F	AF Stock
4500-541500	43B493	Link Assembly - 9-place glider tow rope	03-F	AF Stock
4500-540200	43A2647	Link - 30-place glider tow rope	03-F	AF Stock

<u>Stock No.</u>	<u>Part No.</u>	<u>Nomenclature</u>	<u>Class</u>	<u>Source</u>
4500-905100	43B2648	Thimble - 30-place glider tow rope	03-F	AF Stock
4500-905150	42A9485	Thimble - 2-place glider tow rope	03-F	AF Stock
4500-542000	43A1786	Link - 2-place glider tow rope swing	03-F	AF Stock
4500-733800	42A9390	Ring Assembly - 2-place glider tow rope	03-F	AF Stock

Note: Part No. 43D537 tow rope assembly – 9-place glider, and Part No. 43D538, tow rope assembly - 2-place glider and parts of such assembly for replacement have not been procured for general AF Stock due to limited use.

P. Glider Snatch Pickup

(1) The aerial retrieval nylon tow rope for the CG-4A is 225 feet long and 15/16" in diameter. It is attached to closed loop of 15/16" nylon rope 80 feet in length. The latter is suspended between two 12 foot stanchions placed 20 feet apart. Just aft of the glider tow plug an 18 inch length of 11/16" nylon tow rope is added to the tow rope as a safety link. The retrieving aircraft is equipped with a winch drum that contains 1000 feet of 5/8 inch steel cable that is played out as needed and then braked. The glider is then reeled in to the normal tow rope length behind the tow plane.

Q. AAF Manual No. 50-17

(1) AAF Manual No. 50-17, "Pilot Training Manual for the CG-4A Glider," dated March 1945, states the following:

"For double tow, a 350-foot 11/16 inch nylon rope attached to the nose of the glider on the left, while a 425-foot rope is attached to the nose of the glider on the right."

R. British Combat Gliders

(1) According to Nick Nicholls, a WWII British glider pilot, the British Airspeed Mark II Horsa and General Aircraft Hamilcar I combat gliders were towed with a 300 foot hemp or Manila rope, 2 inches in diameter. The yoked tow rope used to tow the Mark I Horsa was also 300 feet in length. A 300 foot nylon tow rope, about 1.5 inches in diameter was used for snatch pickups.

Note: This research paper was written during the week of first week of June 2003. A copy was furnished to the archives of the Silent Wings Museum in Lubbock, Texas, at the request of that institution.

Source Data: The initial data on the development of nylon was furnished by Charles L. Day of Lambertville, Michigan, author of "Silent Ones - WWII Invasion Glider Test and Experiment." The other data taken from AAF Technical Order 09-1-13, dated 13 December 1943, and AAF Manual 50-17, "Pilot Training Manual for the CG-4A Glider," dated March 1945.

Source Data: The initial data on the development of nylon was furnished by Charles L. Day of
Lambertville, Michigan, author of "Slit-Ones - WWII Invention Glider Test and Experiment."
The other data taken from "The Development of Nylon" by the Army Air Corps, dated 11 September 1943, and AAF
Manual 20-17, "Pilot's Manual," dated March 1943.



Figure 1 - Illustrating Cuts and Abrasions



Figure 2 - Illustrating Cuts and Abrasions



Figure 3 - Illustrating Backturns



Figure 4 - Illustrating Backturns



Figure 5 - Illustrating Burns



Figure 6 - Illustrating Broken Strands



Figure 7 - Illustrating Fusion

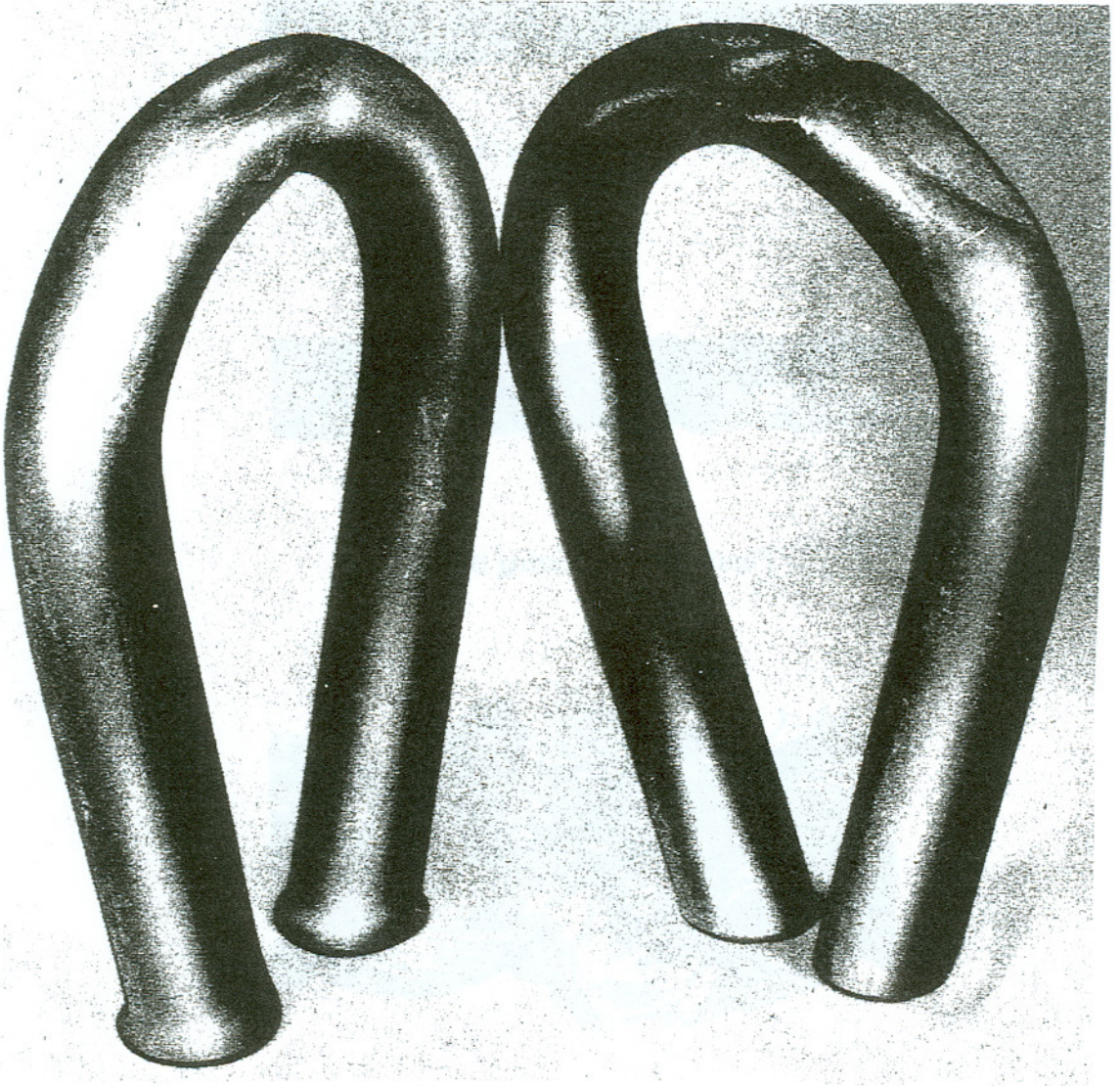


Figure 8 - Illustrating Defective Hardware

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