



PKBWM

PAŃSTWOWA KOMISJA BADANIA
WYPADKÓW MORSKICH

FINAL REPORT

028/21

a serious marine casualty

Sailing ship *Dar Młodości*
and
Tug boat *Fairplay IV*

Rupture of a tow line during mooring manoeuvres on
22 April 2021 in the port of Gdynia

February 2022



The investigation of a serious casualty that occurred on board the sailing ship *Dar Młodzieży* was conducted under the Act of 31 August 2012 on the State Marine Accident Investigation Commission (Journal of Laws of 2019 item 1374) and the norms, standards and recommended practices agreed upon within the International Maritime Organisation (IMO) that are binding for the Republic of Poland.

In line with the provisions of the above-mentioned Act, the purpose of the investigation of a marine casualty or incident is to determine its circumstances and causes in order to prevent marine casualties and incidents in the future and improve safety at sea.

In the course of its investigation, the State Marine Accident Investigation Commission determines neither liability nor apportions blame to persons involved in the marine casualty or incident.

This report shall be inadmissible in any criminal or other proceedings aimed at attributing blame or liability for the casualty referred to in the report (Act on SMAIC Article 40 para. 2).

State Marine Accident Investigation Commission

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1. Facts

On 22 April 2021, at 6:50 am, a pilot went aboard the sailing ship *Dar Młodzieży* that was lying at anchor and manoeuvres started to enter the port of Gdynia (via southern entrance). At 7:17 am the tug boat *Fairplay IV* approached to its stern and gave the tow line with a section of high elasticity to protect against excessive jerks. Once she passed the entrance heads of the port and Entrance Quay and then entered the President Basin, the person controlling the tug boat was instructed to pull the stern of the ship into the President Basin so that *Dar Młodzieży* could moor with its starboard to the Pomorskie Quay. When the tow line got abruptly tightened, at 7:30 am the tow line ruptured and the end of the ruptured elastic tow line hit the third officer on the chest as he was overseeing the manoeuvres at the stern.

After the ship doctor conducted a forensic medical examination of the victim, a rescue team was called to transport the victim to a hospital.

2. General information

2.1. Vessel details

2.1.1. Tug boat *Fairplay IV*



Photo 1 – Tug boat Fairplay IV



Vessel name:	<i>Fairplay IV</i>
Flag:	Polish
Operator:	Fairplay Towage Polska, Sp. z o.o. Sp. k
Classification society:	PRS
Vessel type:	tug boat
Call sign:	SPG3973
IMO identification number:	7803451
Gross tonnage (GT):	55
Year of construction:	1978
Power:	2 x 640 KW
Width:	8.80 m
Overall length:	26.32 m
Hull material:	steel
Minimum crew:	3 – domestic shipping (5 – coasting)

2.1.2. SPS¹ *Dar Młodzieży*



Photo 2 – Sailing ship Dar Młodzieży

¹SPS – Special Purpose Ship – a prefix consistent with the Ordinance of the Minister of Marine Economy and Inland Navigation of 9 January 2020 (Journal of Laws of 31 January 2020 item 153).



Vessel name:	<i>Dar Młodzieży</i>
Flag:	Polish
Operator:	Gdynia Maritime University
Classification society:	PRS
Vessel type:	sailing ship - full-rigged ship
Call sign:	SQLZ
IMO identification number:	7821075
Gross tonnage (GT):	2255
Year of construction:	1981
Power:	2 x 750 KM
Width:	14.00 m
Overall length::	106.80 m
Hull material:	steel
Minimum crew:	17 people
Type of the VDR (S-VDR):	none

2.2. Information on voyage of the vessel

Ports of call during voyage:	Antwerp
Port of destination:	Gdynia
Type of navigation:	international
Information on cargo (quantity, type):	no stowage – a training ship
Information on crew (count, nationality):	32 + 4 (lecturers), Polish nationality
Information on cadets:	114

2.3. Information on marine casualty or incident

Type of casualty/incident: (e.g. serious)	Serious marine casualty
Date and time of occurrence:	22 April 2021, at 7:30 am
Geographical region of occurrence:	Port of Gdynia, President Basin,
Nature of water body:	Port waters.
Weather during occurrence:	Wind SW-5°B, good visibility.
Operational status of vessel during occurrence:	Manoeuvres, entering the port, mooring.



Place of casualty/incident on the vessel: Aft deck of the sailing ship.
Consequences of casualty/incident: Chest injury. 40 days' sick leave.

2.4. Information on shore-based entities involved and rescue operations

Involved entities: Emergency response team.
Response time, operations of rescue services: Immediate, upon a call from the duty officer at the port of Gdynia.
Action taken: Provision of first aid and transportation of the victim to the hospital.

3. Description of circumstances of casualty/incident

On 22 April 2021, the sailing ship *Dar Młodzieży* finished her voyage from Antwerp and after arriving at the anchorage of the port of Gdynia at 00:51 am, she dropped the right anchor.

After the night at anchor and heave up the anchor at 6:50 am, she started manoeuvres to enter the port of Gdynia. The ship headed towards the Southern entrance to the port of Gdynia. At 6:50 am, a port pilot went aboard and at 7:17 am the ship received the tow line through the Panama lead from the tug boat *Fairplay IV*.

The ship was proceeding at the speed of 3 kn^2 and at 7:30 am she passed the beam of the entrance heads and then, reducing her speed, she proceeded to the corner of the Entrance Quay and Pomorskie Quay in the President Basin. At the same time, the tug boat followed the stern of the ship, with its loose tow line buoyant. The tow line passed from the tug boat to the stern was composed of 4 rope sections. The first section passed to the deck of the sailing ship was a polyolefin and polyester rope with a length of approx. 20 m and diameter of 56 mm, featuring an extensibility of 20% at full breaking load. It was deemed to be a sort of “spring” and protection on account of the low extensibility of the other rope sections used in the tow line. The other 3 sections, 5 m each, were made of HMPE³ rope with a diameter of 32 mm. The extensibility of the HMPE rope at full breaking load is barely 3%. The ropes were joined with each other in a permanent manner by interleaving rope eyes.

² Unit of measure equal to one nautical mile per hour (approx. 1.852 km/h)

³ HMPE is a chemical name for high modulus polyethylene: an increasingly popular material used to make different types of rope. The polyethylene fibre is produced by gel-spinning, in which fibres are drawn, heated, elongated and cooled. Stretching and spinning leads to molecular alignment, high crystallisation and low density. The quality of HMPE ropes differs a lot depending on the manufacturer.



Photo 3 – The method of joining tow line sections.

As it was planned to moor the ship with its starboard to the Pomorskie Quay, the pilot instructed the person controlling the tug boat to move to the port side of *Dar Młodzieży* and pull her stern away towards the interior of the President Basin so as to turn the ship's bow so that it should face the exit. At the time, the tug boat manoeuvres were conducted by an officer training under the supervision of the master. While conducting the manoeuvre as instructed, the person controlling the tug boat caused an abrupt tightening of the tow line⁴. The tow line ruptured where the eyesplice ended on the first tow rope after the “spring” rope.

⁴ All the crew participating in the manoeuvres that watched the tow line tightening confirm the fact that the tightening was quite quick and caused a strong jerk which ended in the breaking off of the tow line.



Photo 4 – The rope section treated as a “spring” and the end of the ruptured tow line.

The crew at the manoeuvring station on the stern had previously received an instruction to move away from the operating tow line and they hid behind the superstructure on the stern, on both sides. The third officer in charge of the crew at the stern manoeuvring station, stood behind the capstan, which provided a shield, in order not to stand in the line of the operating tow line.



Photo 5 – The stern central chock and the capstan behind which the third officer stood during the tow line operation.



As a result of a strong spring action, the end of the ruptured tow line snapped back on aftdeck of the sailing ship and bouncing from the capstan with a great force, it hit the third officer standing behind the capstan on his chest. The victim fell from the force of impact and was dizzy. The ship doctor was called and provided first aid. The duty officer at the Harbour Master's Office in Gdynia was informed about the occurrence. At an instruction from the Harbour Master, an emergency response team was called in.

As for the tug boat *Fairplay IV*, her master took over the control and moved up to the ship's stern at the pilot's instruction. A new tow line was passed and manoeuvres were continued to come alongside the quay. At 8:15 am, *Dar Młodzieży*” moored at the Pomorskie Quay.

An ambulance was already waiting at the quay. Upon an examination, the victim was taken to the hospital.

4. An analysis and remarks concerning the factors that led to the marine casualty or incident, considering the results of investigations and experts' evaluations

The tug boat *Fairplay IV* belongs to an older generation of tub boats; it is propelled with two azimuth thrusters – ATD⁵ that allow for highly precise manoeuvring. The tug boat does not have a towing winch with a system for automatically adjusting the pull force under load, but only a tow hook and winch for hauling away of slack tow lines onto the drum. At present, there are generally two types of ropes marketed with a minimum breaking strength comparable to the previously used wire ropes. They are either very thick polyester/polypropylene ropes or new generation HMPE ropes. Those are new generation ropes that are very lightweight, buoyant and easy to operate for the crew. However, their operation implies a number of restrictions and requires relevant knowledge on their properties.

According to information received from the crew of the tug boat *Fairplay IV*, the wire ropes that were previously used as towing lines were replaced with very strong and easy-to-operate HMPE ropes. Clapping on of heavy wire ropes onto the deck by the crew was slow and delayed any manoeuvres underway. The use of HMPE ropes as tow lines solved the issue. The operator supplied the tug boat with tow lines consisting of sections of different lengths that were joined with rope eyesplices. The tow lines could be shortened or lengthened by inserting a rope section of an appropriate length onto the hook. The tug boat *Fairplay IV* had e.g. tow lines consisting of equal 5-metre sections and also tow lines consisting of sections having different lengths, 5

⁵ ATD – Azimuth Tractor Drive



m + 10 m + 15 m + 25 m. As a rule for operation of those tow lines, the first section of the tow line to be passed to the towed vessel was one made of polypropylene rope as a sort of tow spring.

4.1. Mechanical factors

HMPE ropes feature a high strength to weight rate. With a specific gravity of 0.98, a rope remains buoyant. Due to their low weight⁶ and resultant ease of operation, such ropes have been widely used as mooring and towing lines for a decade. Moreover, their long life, resistance to high loads, no corrosion, chemical resistance, resistance to UV radiation, low extensibility (2-3% at rupture) and no absorption of water or stiffening in frosty weather all make operators supply their vessels with those ropes despite their high prices.

Safe towing, however, is a cumulative effect of many factors, the type of rope used being but one of them. Many events related to the use of HMPE ropes for towing (or mooring) have been recorded all over the world, where ropes suffered damage different than damage caused when the previous types of ropes were used⁷. Such damage results from the restrictions that HMPE ropes are subject to during operation. During extensive tests (that are still conducted), it has been determined that the manner of rope operation during towing is crucial and somehow cumulated (remembered) within the rope. Abrupt tightening of such a rope causes a high temperature between the fibres inside the rope and makes them agglutinate, stiffen and become brittle⁸. The fibres have a low melting point, from 144° to 152°C, but even the temperature of around 80°C causes the destruction of rope fibres. As soon as HMPE ropes are inserted through chocks, chain pipes and rolls and laid on bollards, the free movement of fibres in the rope is restricted. In those spots, ropes get damaged against uneven surfaces of the contacted equipment. Their diameter and sometimes their length changes there as compared to undamaged sections. The rope undergoes what is known as compression fatigue. Knots made on HMPE ropes reduce their breaking strength by as much as 50 – 80%. If HMPE ropes are joined to other polyester ropes, the HMPE rope may start twisting due to the axial rotation of the other rope. If a meter of rope is twisted 3 times, it could be weakened by 10%⁹. Note also

⁶ 10 times lower than that of a wire rope having the same diameter.

⁷ CHIRP Maritime – HMPE ropes – Capability with Caution - 2018

⁸ Many towing companies only use HMPE ropes on tug boats that are equipped with towing winches having a system for automatically adjusting the pull force under load, which largely eliminates rapid jerks and reduces the variable loading of the rope while waving.

⁹ The type and model of rope to be used as the spring for the HMPE rope in operation should be specified by the HMPE rope manufacturer. Moreover, some rope manufacturers suggest that the spliced end of the tow line should



the fact that splicing that forms loops at the rope end also disturbs the tight lay of the rope and thus the rope is weakened where it is spliced¹⁰.

An issue related to the operation of HMPE ropes consists in the fact that rupturing often occurs under a lower load than during previous works where higher loads were present. The above-mentioned basic factors that reduce the rope strength and lead to their destruction over time should be taken into consideration when evaluating the rope condition and qualifying the rope for further operation.

4.2. Human factors

In connection with its investigation, the SMAIC determined that the crew of the tug boat *Fairplay IV* and other employees of the operator did not have the required knowledge on how to operate HMPE ropes. In the crew's opinion, the first section of a polyester rope treated as a spring should be weaker than the passed tow line (HMPE rope) by approx. 20%. The task of rope so selected was to protect the (HMPE) tow line against breaking off due to the high prices of tow lines. In a critical situation, the polyester rope section (spring) was supposed to break off and not the tow line. As the polyester rope section passes through chain pipes, chocks and guiding rolls, damage is done to rope surface but on the spring section only.

In fact, the task of the springing section of the rope is to reduce abrupt tightening of the tow line and reduce its compression fatigue, especially where there is no mooring winch with a system for automatically adjusting the pull force of the rope under load. As regards safety, when an HMPE rope breaks off, its rebound is low due to low extensibility.

The selection of a rope used as a spring should be recommended by the HMPE rope manufacturer and correspond to its parameters¹¹.

In the SMAIC's judgement, the rope sections used as the tow line passed to the sailing ship *Dar Młodzieży* showed damage caused by previous operation. Where the rope ruptured, i.e. at the end of the HMPE spliced loop and its junction with the rope used as the springing section, one could see damage and melting on strands. The damage was due to high temperature during the reciprocal movements of the rope fibres.

be joined with the spring rope not by simply interleaving them but with a square knot arrangement. With such connections, it is possible to separate rope sections easily, without untwisting (cutting off) of rope ends.

¹⁰ This is where the tow line passed from the tug boat *Fairplay IV* ruptured.

¹¹ Such requirements are exemplified by the use of rope sections as springs in the Suez Canal by ships that use HMPE ropes as mooring lines. Such ropes need to have manufacturers' certificates to be used in connection with mooring lines.



Photo 6 – The end of the damaged HMPE rope

The other section of the ruptured tow line that was provided for visual inspection by the management of Fairplay Towage Polska Sp. z o.o. Sp. k. looked similar.



Photo 7 – A section of the ruptured tow line

The ends of interleaved ropes of the eye were not stitched in compliance with a technique recommended by rope manufacturers, which additionally increased the extent to which rope terminations slid against the core, thus raising the temperature due to friction¹².



Photo 8 – A correctly spliced eye of an HMPE rope with visible stitches restricting the movement of spliced strands.

¹² There is another type of HMPE rope eye splice (Brummel) which does not require stitches but it weakens the rope at the splice almost twice.

The tug boat crew could not answer the question whether joining short sections of ropes to make a tow line of appropriate length is the right solution. Ropes supplied by the operator's services in specific joining configurations had not been previously consulted with the tug boat crew. The crew claimed that they did not have any specific knowledge on the operation of tow lines with HMPE-type ropes used.

Fibre damage that disqualified the rope from use was visible under the rope's (yellow) sheath in the areas of intense rubbing of the ruptured end of the HMPE (tow) rope.



Photo 9 – Damage visible upon removal of the sheath from the rope eye.

The crew on the tug boat was aware of the danger involved in the snapping of a tow line and there is nobody on the aftdeck during the operation of the tow line.

Aboard *Dar Młodzieży*, the third officer in control of the manoeuvres told the crew to leave the aftdeck after the tow line had been passed and hide behind the walls of the superstructure. He remained on the aftdeck and stood behind the capstan though.



Photo 10 – The deck of the sailing ship *Dar Młodości* with the capstan visible in the centre of the aftdeck

It was a highly insufficient protection against the possibility of being hit by the end of a ruptured rope. Watching the operating tow line, especially from that close, poses a great danger and does not contribute in any manner to the manoeuvres conducted. It is impossible to attempt to lurch away and not be hit by the ruptured rope because the ends of ruptured ropes reach the speeds of several hundred kilometres an hour. Luckily for the injured officer, he was hit by the end of the rope that had already bounced from the capstan he was standing behind.

4.3. Organisational factors

In line with the Safety Management System Book (KZB) used by Fairplay Towage Sp. z o.o. Sp. k. and the procedure included in the book for the tug boat technical condition maintenance, the chief officer is responsible for the mooring and towing devices and equipment¹³. In line with the provision of Section 6.3. of the procedure, *inspections of mooring, towing and handling equipment shall be conducted in a six-month cycle and regardless of the condition check of the equipment before and after every use.*

An inspection conducted by the chief officer and crew every six months is confirmed with a filled-in form F. PS – 06/4. The section devoted to “*Towing equipment*” includes a rating scale, i.e. *good, satisfactory, disqualification*. No other additional criteria are mentioned that would enable one to describe accurately the condition of tow lines. During the last inspection that was

¹³ Ref. no. PS-06 of the ship procedures for the vessel maintenance.



conducted on 6 January 2021, the condition of the tow line used for the towing service carried out during the manoeuvres of *Dar Młodzieży* was considered to be *good*.

Taking into account the characteristics and complex properties of high modulus polyethylene fibres that HMPE ropes are made of, such limited check activities seem insufficient. The person who conducts visual inspections and checks of tow lines does not have sufficient knowledge to conduct their check or evaluation of the rope condition for further operation. Checks should be conducted much more frequently by crew members (operator's representatives) previously trained to carry out such tasks or by a representative of the rope manufacturer.

Large towing companies have introduced monthly checks of HMPE ropes by their staff with preparation for such evaluation.

Leading rope manufacturers recommend keeping a separate log for every HMPE tow line and entering all work conducted using the tow line and conditions of its use¹⁴. Some companies that manufacture HMPE ropes also provide courses and training for people tasked with rope condition evaluation.

4.4. The impact of external factors, including those related to the marine environment, on the occurrence of the marine casualty

External factors had virtually no impact on the occurrence of the accident.

5. Description of the investigation results, including safety issues and conclusions of the investigation

Difficulties related to the condition evaluation of HMPE ropes and their capability for further operation are subject to research conducted by a number of academic facilities¹⁵. Research is conducted into the possibilities to use magnetic fields, capacitive methods, current flow, computer scans, CT scanning or tests using optical methods, vibrations, acoustics or temperature measurements. Effective techniques for rope condition evaluation are sought in those areas. With a visual inspection even if conducted by a trained person, one cannot be entirely confident about the condition of rope fibres which determines the capability of the rope to take large loads. Premier rope manufacturers strive to help trained users of such ropes, by indicating control methods, types of damage and relevant procedures¹⁶.

¹⁴ E.g. Sampson Rope – Marine, Dyneema Rope.

¹⁵ Such as the University of Agder in Norway. Study: *Condition Monitoring Technologies for Synthetic Fiber Ropes – a Review*.

¹⁶ For example – *12 – Strand Rope Inspection & Retirement – Quick Reference Checklist*, Sampson Ropes.



The following factors had a decisive influence on the accident that occurred aboard *Dar Młodzieży*:

- pulling abruptly the tow line that previously was completely slack¹⁷,
- the victim staying on the aftdeck, in an area that should be treated like a possible snap-back danger zone in case the tow line is ruptured,
- using a rope that was weakened through its previous use.

As regards the condition evaluation of the entire tow line passed from the tug boat *Fairplay IV*, the SMAIC had a difficult task because the damaged tow line section that remained on the deck (side) of the tug boat was decommissioned and cut up into shorter pieces before a representative of the SMAIC could carry out a visual inspection.

The accident occurred on 22 April 2021 but was only reported by the master of *Dar Młodzieży* by phone on 29 April 2021 when the ship was at sea. The representative of the SMAIC could visit the ship and investigate the accident details on 7 May 2021 after the ship arrived at the anchorage of the port of Gdynia. The tow line section that had remained on the aftdeck of the sailing ship was collected then and underwent visual inspection.

6. Safety recommendations

6.1. Gdynia Maritime University (operator of the sailing ship)

The State Marine Accident Investigation Commission recommends clear marking of snap-back danger zones for ruptured tow and mooring lines where nobody should stay during the operation of ropes under load.

The SMAIC also reminds of the statutory obligation to report a marine casualty or accident that binds the ship operator or master concerned pursuant to the Act on SMAIC Article 47 point 3 (Journal of Laws of 2019 item 1374).

6.2. Fairplay Towage, Sp. z o.o. Sk. k (operator of the tug boat)

The State Marine Accident Investigation Commission recommends that training be provided for those tasked with the technical condition evaluation of HMPE-type ropes operated on tug boats. In the SMAIC's judgement, ropes should undergo a condition check and qualification for further operation more frequently than once every six months. The SMAIC also recommends that the proper use of lines consisting of sections of joined spliced ropes and the

¹⁷ According to the information received from the crew of *Dar Młodzieży*, when the tow line got abruptly tightened the angle between the tow line and the axis of symmetry of the sailing ship was approx. 45°.



selection of a polyester rope which is to compensate for any abrupt tension variations in HMPE ropes be consulted with the rope manufacturer.

The SMAIC recommends that training be provided for tug boat crews so that they learn the properties of HMPE ropes and rules for their use during towing operations.

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8. Composition of the accident investigation team

Head of the team - Marek Szymankiewicz - Secretary of the SMAIC

Member of the team - Monika Hapanionek - Member of the SMAIC