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SEA-ME-WE 4 Fibre Optic Submarine Cable Project

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Abstract

In the fast expanding world of technology, the internet has become an essential backbone in transferring data and information to business's and markets world-wide. With data needed to be transferred to countries oceans apart on a daily basis, a medium to transport this large volume of data at a high rate is required for global economies to perform at maximum efficiency. The South East Asia-Middle East-West Europe 4 (SEA-ME-WE 4) fibre optic sub-sea cable is such a medium capable of transporting large volumes of data on a global scale within the blink of an eye, making it ideal for global economies to conduct business with efficiency.

The SEA-ME-WE 4 sub-sea cable currently spans 20,000 km linking South East Asia, The Middle East, North-East Africa and Western Europe. The fibre optic system was constructed using a Cable Ship and equipped with a Sea Plough designed to dig trenches, lay cable in the trenches and cover the cable under the sea bed. The system uses state-of-the-art Terabit technology to achieve ultra-fast data transfer (1.28 Terabits/second), and supports a wide range of communication media from telephone, internet, multimedia and various broadband applications. The SEA-ME-WE 4 consortium, comprised of sixteen international telecommunication companies, currently performs maintenance on the system, providing Cable Repair Ships to respond to areas where the cable has been cut or disrupted.

The following paper will highlight the construction of the SEA-ME-WE 4 cable, the procedures used in laying the cable, the impact the fishing industry has on submarine cables like SEA-ME-WE 4 and how to prevent submarine cable damage.

Introduction

In 1986, the first cable of the SEA-ME-WE series (SEA-ME-WE 1) was constructed using a coaxial cable designed to transmit telephone signals between Europe, the Middle East and Southeast Asia. Upon completion, it was the longest telephone cable in the world spanning 13,585 km, and was the first cable to be laid in the Indian Ocean. The cable was completed in 8 sections; the third section consisted of a terrestrial cable laid across Egypt. Segments of the cable laid in shallow water were armoured with steel wires to protect it against ship anchors and fishing trawlers. Approximately 85% of the cable was laid in deep water containing no armour. The maximum bandwidth of the cable was calculated to be 25 MHz. To date the SEA-ME-WE 1 cable has become obsolete due to higher demands of broadband and data transfer, leading to the construction of the SEA-ME-WE 2, 3 and 4 projects (See Figure 1a and 1b).

The SEA-ME-WE 2 project was installed on October 18th, 1994. The project consisted of a fibre optic cable system, spanning 18,751 km, linking 13 countries and three continents.

The peak capacity of the cable reached 560 Mbps, which is approximately equal to the capacity of fifteen SEA-ME-WE 1 cables. Five years later, the SEA-ME-WE 3 cable was completed with a capacity of 2.5 Gbps, which was later upgraded to 10 Gbps in 2002. The cable accommodates even more countries than SEA-ME-WE 2 extending past Jakarta towards Australia, Singapore and Japan, spanning a total 38,000 km. It is currently the longest sub-sea fibre optic cable in the world consisting of 39 landing points connecting 33 countries and over 2 billion people. The final project in the series, the SEA-ME-WE 4 cable, currently has a capacity of 1.28 Tbps, and spans 20,000 km. The SEA-ME-WE 3 and 4 cables currently provide backup for one another in case one cable should be cut or disrupted.

Submarine cable composition

The first submarine cable was created in 1851 Britain as an international telegraph cable connecting Dover to Calais. Within fifteen years, the cable industry in Britain expanded and created the first transatlantic cable, which was laid between Newfoundland and Ireland. The composition of the cables consisted simply of a copper conductor wire, gutta percha insulation and outer wire armouring. In those days there was no electrical engineering profession, only practicing electricians with limited knowledge of signal theory, basing most of their designs on experimental results. Modern fibre-optic cables such as SEA-ME-WE 4 use strands of fibre optic wires surrounded by polyethylene insulation, combined with plastic and stranded steel wire armouring layers (See Figure 2a and b).

In the 1850's, the conductivity of the wire or the ability of the wire to transmit signals over long distances depended on the purity of the copper. As cable production and demand for longer cables increased, so did the refinement and purity of the copper wire to be able to transmit the signal over longer distances. William Thomson, a British mathematician and physicist in the 1850's, was the first to develop the first stranded copper cable in 1857. Cables developed in strands helped the overall flexibility of the cable, and the ability of the cable to protect signal transmission should a few wires become damaged. Modern cables such as SEA-ME-WE 4 use glass fibre optic conductor strands the size of a human hair, typically between 6-24 fibres. Computers send sounds and data in the form of digital pulses, which are shot by lasers through the fibre optic strands in the form of light. The digital pulses are received on the other end by a computer, and are then converted back to sounds and data.

The gutta percha insulation was developed from the sap of tropical trees, and created a latex inelastic layer around the copper wire. As a thermoplastic material, it would harden and become more solid under high pressures and cold temperatures, making it ideal for sea bed conditions. Gutta percha was used until the 1930's for subsea cables, until the development of polyethylene insulation. The SEA-ME-WE 4 submarine fibre optic strands are insulated by a medium density polyethylene cover, and a copper sheath designed to carry electricity to repeaters. Repeaters are normally spaced 30-80 km apart and can cost up to one million dollars per repeater.

The armouring of cables is provided to improve the structural strength of the cable from stresses due to laying, as well as protect the cable from marine animals, abrasion from the sea bed and ship anchors. The Dover-Calais cable was armoured with four strands of copper wire followed by two layers of gutta percha arranged into a square cross-section, the gaps of which were filled with tarred hemp. A spiral of ten iron wires was then wrapped around the cable to complete the armouring. The overall diameter of the cable measured 1 ¼ inches and weighed 7-8 tonnes per mile of cable.

After extensive research into wire technology to protect coal miners in Britain from falling down shafts, the Newall's wire rope was developed. The Newall wire rope consisted of iron wires wrapped around a core of hemp. The hemp core was used to hold the wires at equal distances from each other creating uniform stresses in the wire, therefore reducing the likelihood of localised failure. After the failure of the Dover-Calais cable, Newall proposed to armour a cable by introducing it within the hemp core of a Newall wire rope, thus creating uniform stresses along the wire, and less chances of the cable being damaged during and after laying. At present, the SEA-ME-WE 4 cable is armoured in two layers of tar covered galvanized steel wires and three tar soaked nylon yarn layers, having a total outer diameter of 2 inches (See Figure 2a and b).

Submarine cable installation

Submarine cables that are laid and buried in the sea bed require detailed surveying of the topography of the ocean floor before any installation takes place. The route of the cable has to consider many important factors such as fishing areas, areas near ports where ships anchor, fault lines, sediment types, slopes and water depth. Cables laid near existing cables and pipelines must take care not to cause damage to these cables, and must consult the owner of the existing cables should routes cross paths. The laying procedure of the cable takes place through a cable layer ship equipped with a sea plough, used to dig trenches and backfill, as well as remotely operated underwater vehicles to detect and retrieve damaged cables(ROV).

The SEA-ME-WE 4 cable was laid by Cable Ship Niwa (Figure 3a), which is owned and operated by Emirates Telecommunications and Marine Services (e-marine). Phase I of the project took 101 days to complete, laying 3500 km of cable in depths up to 4000 meters from France to the Arabian Sea. Omar Bin Kalban, CEO of e-marine, stated that, "The cable was laid within one metre of its designated location on the seafloor, an indication of absolute positioning accuracy." Niwa uses Differential Global Positioning Systems(DGPS) to ensure the cable is being laid as close to the route as possible, and that the specified design length is used. The system also helps track the cables positioning should it become damaged and need to be repaired. Phase II of the project was completed by Fujitsu ltd and Alcatel Submarine Networks. In December 2004, a devastating Tsunami hit the coast near the Bay of Bengal delaying the start of Phase II. Fujitsu resurveyed the ocean floor and found there were no serious threats that would compromise the route.

CS Niwa maintained a speed between zero to seven knots during the laying procedure to avoid exceeding the tensile capacity of the cable. Manufacturers provide cable laying ships with charts and data, based on historical and experimental results, on safe speeds to maintain, as well as the tensile capacities of the cables. Buoys are often attached to cables near shore and landing points to warn other vessels, as well as ensure the cable doesn't hit the seabed with damaging force (Figure 3b). After the cable is laid, the buoys are removed and the cable sinks gently to the ocean floor. When the bottom of the sea bed has high turbidity currents, the cable may be shifted off its intended path by some distance requiring all other vessels, such as trawling fishing vessels, to give cable laying ships up to a one nautical mile berth. All vessels must maintain a one nautical mile berth while the cable ship has its laying signals on to avoid vessels becoming entangled on the cable, endangering the lives of people and their equipment.

Cable Damage and Prevention

One hundred to two hundred submarine cables become damaged each year, with over two thirds of the incidents involving fishing vessels. In 1850, a submarine cable spanning across the English Channel failed a few days after it was laid because a fishing crew thought it was a special kind of seaweed, and cut into it to take a sample. At this time cables had no armouring to protect the wires, until 1851 when the first armoured cable was developed. The minimum bend radius of a fibre optic cable is between 1-1.5 meters, meaning that a fishing trawler could fracture the strands without even completely severing the cable.

Recently in 2008, the SEA-ME-WE 4, FALCON and FEA cable were all cut near Alexandria, Egypt. It was widely believed that a fishing vessel dragged their anchor across the cables severing all three. Egyptian authorities denied any report of a fishing vessel located in the area during the time of the disruption, stating they had video evidence of the coast at the time of the breakage to support their claim. The incident affected 91.1 million internet users in Asia, The Middle East and North Africa. The difficulty in obtaining work permits for the cable repair ship to cross international waters delayed the repair process by one month. The cost of fixing the cables cut exceeded 1 million US dollars, including other damages incurred to equipment on land and sea that was paid by telecommunication companies.

Fishing crews are advised to contact the coast guard, or owner of the cable, should they become entangled for their own safety and the safety of the equipment. In some areas, however, fisherman may be held liable for the cost of the repair and may even face criminal charges. In September, 1956, Pat Hastings, a technical officer for a transatlantic cable project, witnessed lines being cut by fisherman due to entanglement, saying,"In the early days there were a few problems with cable failures largely because fishing boats, who were doing deep sea trawling, tended to catch hold of this cable which was only laying on the sea bed not in the deep sea portions, but in the little continental shelf areas coming off the main continents, particularly in America where the continental shelf extends I believe a hundred and fifty miles or so, and deep sea trawlers would fish up the cable and obviously get it all tangled up with their boards and what-have-you and officially they were supposed to notify the companies, that's AT&T and the Post Office what they had done, but I'm afraid they weren't always very honest and it was on one or two occasions quite obvious that the axe had come out and chopped the cable in half."

In order to prevent or limit fibre optic cables from incurring damage they are armoured and buried a certain depth underneath the sea bed to protect them from anchors and fishing gear. For coastal regions, cables are normally buried between 0.6 - 1.2 meters, whereas in heavy fishing areas cables can be buried several meters into the sea bed, making maintenance and repair of the cable difficult. Most cables laid in water of depths greater than 1000 m and on rocky surfaces are not buried; however there are special sea ploughs that are capable of burying cables in these conditions.

The United Nations Convention on the Law of the Sea (UNCLOS) was developed in 1982, and currently holds 157 member nations. The document contains clauses to protect cable companies and fisherman in case of a cable break, and to identify which party is liable to pay for damages. According to UNCLOS, fishermen are required to fish at a safe distance from known cable paths, and to practice safe works and procedures to avoid damaging cables. Nautical charts identifying cable routes should be kept up to date on vessels, and are free to download from online sites like The International Cable Protection Committee (ICPC). By law, if a submarine cable becomes damaged by a fishing vessel performing unsafe practices then the fishing vessel is liable for the damages. The fishing captain will have to pay a fine in addition to the cost of damages, and may even have their ship impounded. If the damages are caused through emergency actions trying to save the vessel and crew from danger, then no liability is incurred. The laws also go on to state that fishing gear attached to a cable should be cut rather than the cable. There have been several cases where owners, cable companies, have reimbursed fishermen for their damaged fishing gear.

Conclusions

The laying of the SEA-ME-WE 4 cable brought with it many advantages in the area of internet technology, benefiting several nations and billions of users with highly consistent internet speed and communications. However, natural and man-made disasters still compromise the safety of submarine cables like SEA-ME-WE 4, and its ability to support internet users.

With fishing vessels being the cause of more than two thirds of total cables damaged per year, as well as the SEA-ME-WE 4 cable being cut in 2008, cable companies and organizations such as the ICPC have attempted to raise awareness of submarine cables to fishermen by providing free nautical cable charts, and publications on submarine cables. However, many fishermen believe that cable routes cut into their good fishing spots, thus affecting their livelihoods. With having to paying heavy fines for damaging cables, fishermen feel less inclined to follow the law of the sea and treat submarine cables with respect, adding danger to themselves and the integrity of the cables.

In recent years, cable companies have started informing fishing communities on proposed cable routes, and in turn fishing communities have advised cable companies on areas where heavy fishing occurs resulting in safer routes for cables to take. Fishing committees have even been formed in some areas to handle issues specific to cable companies laying across their fishing zones. With national laws of the sea varying from area to area, and the UNCLOS unable to unite all nations under it, it becomes clear that better communication between fishing communities and cable companies is required to minimize damage to fishing and submarine cable operations.

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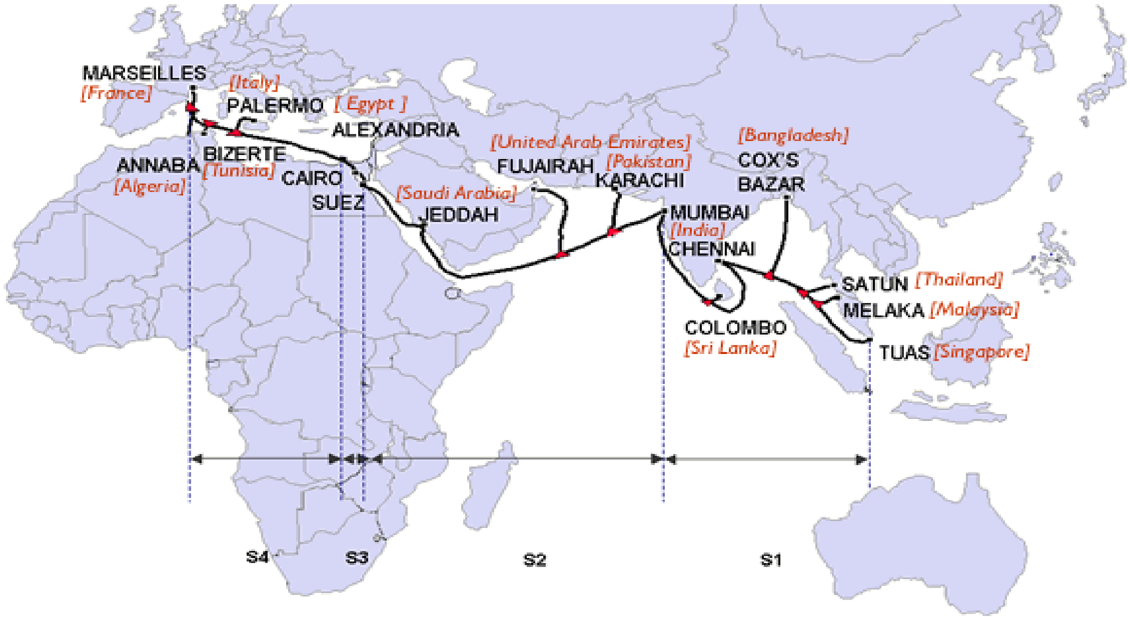


Figure 1a: SEA-ME-WE 4

Figure 1b: SEA-ME-WE 3

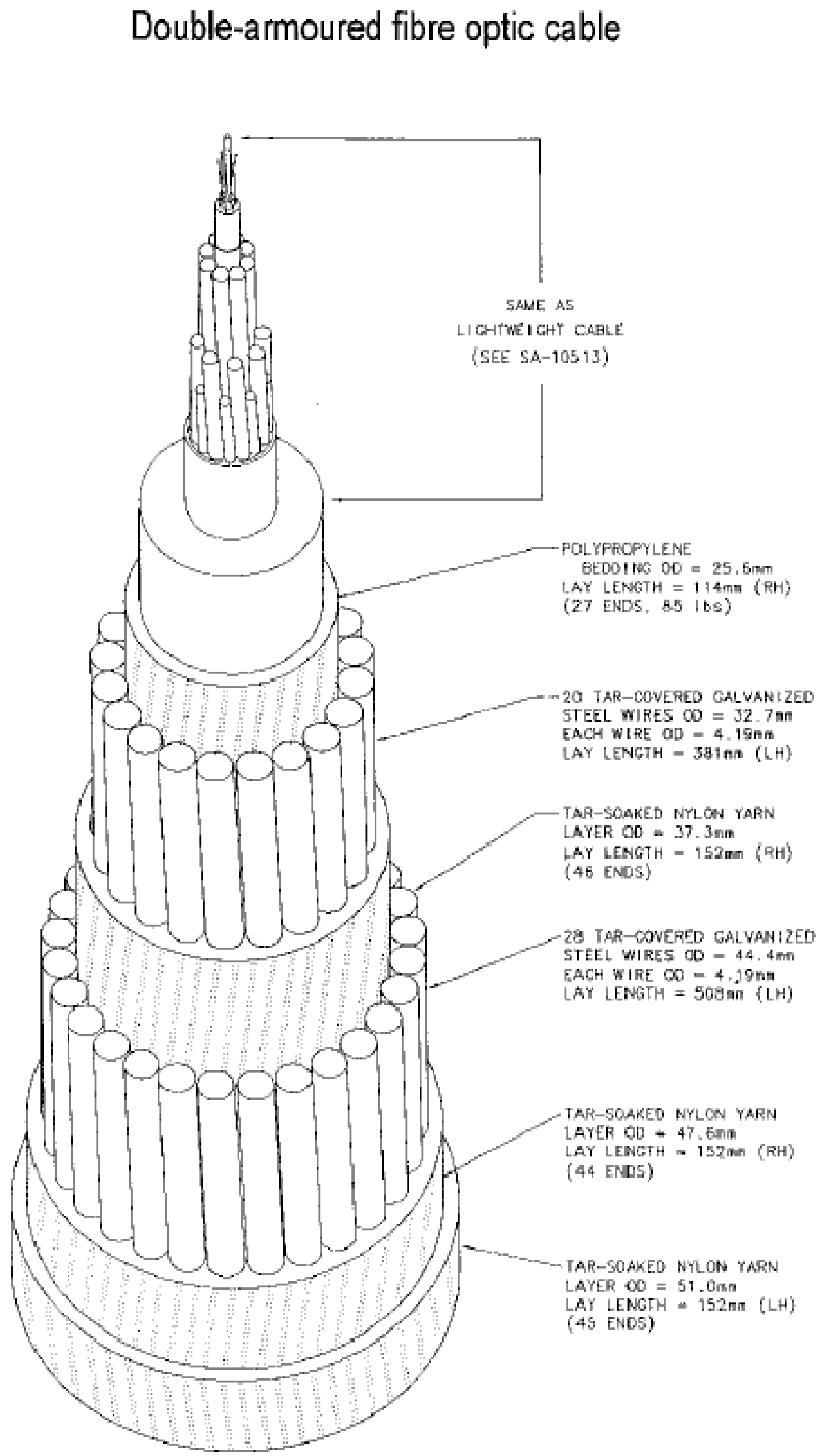
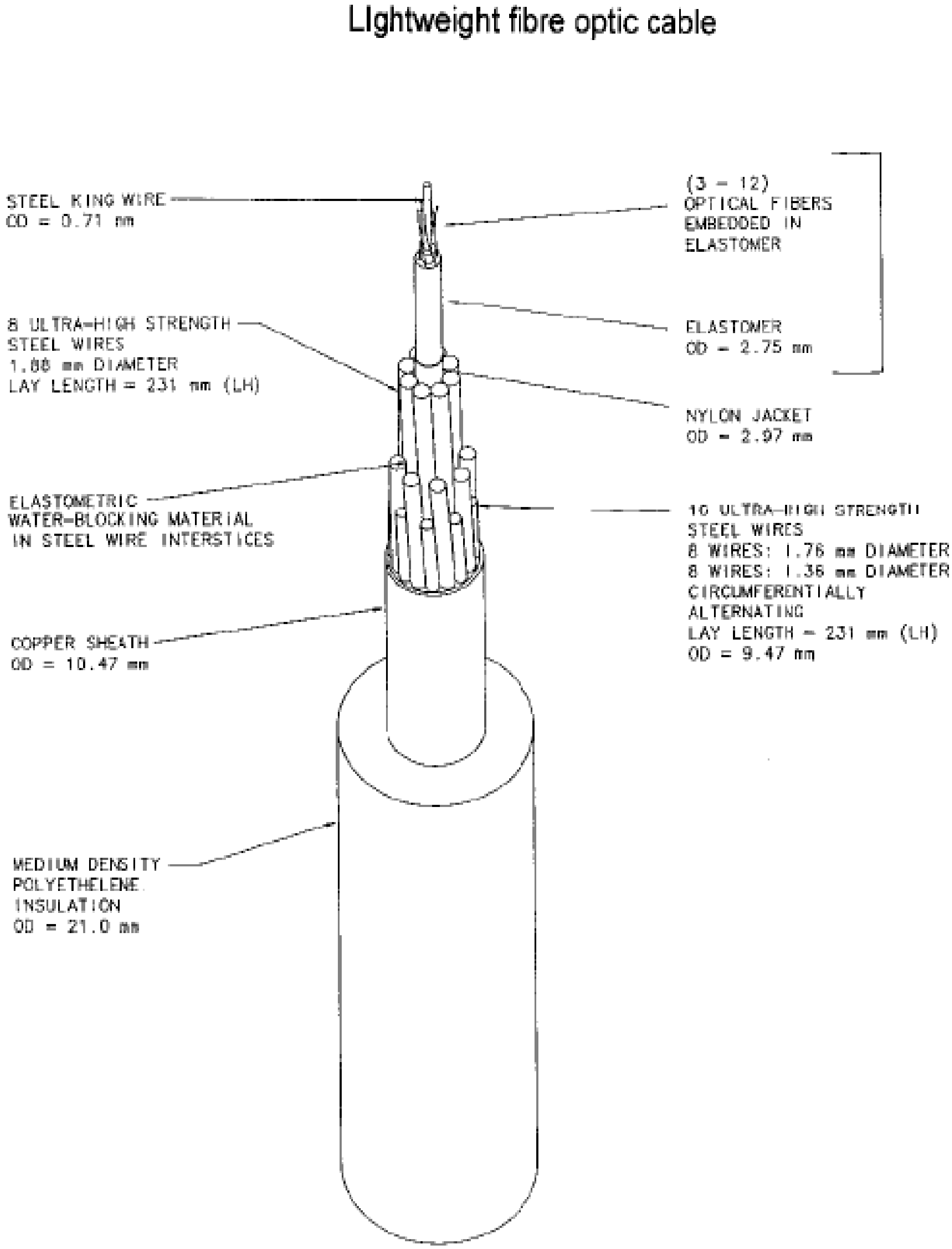


Figure 2a: SEA-ME-WE 4 Fibre Optic Sub-Marine Cable



<u>Figure 2b: SEA-ME-WE 4 Fibre Optic Sub-Marine Cable</u>

Figure 3a: Cable Ship Niwa

Figure 3b: Cable Ship with Sea Plough and Cable Buoys