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Escort Tug – Tow Winch Load Control

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SYNOPSIS

Traditionally, tow winches have not been viewed as highly technological equipment, but active escort tug tow winches are now a critical safety component. The tow winch forms the live connection between tug and tow, and load control performance is crucial to the effective performance of the tug.

The quick release function creates a potentially high power requirement, giving rise to a tendency to make equipment more complicated than necessary. Hydraulic constant tension technology has been used in both the fishing industry's auto trawl systems and the merchant vessel RORO ramp industry for years. This, combined with the development of high power density hydraulic motors and components, gives a simple controllable solution: rather than introducing unfamiliar technology, the electronics of today can enhance the hydraulic muscle familiar with marine winches.

SIMPLE TUG TOWING WINCH

In the past, most harbour tug towing winches had a low, light line retrieval pull with a high-brake holding load. The drive system was de-clutched and the Tow taken on the brake. In an emergency, the brake could be released, allowing the winch drum to rotate freely. The rope clamp would then give way and the tug was safe. Any line alterations required vessel power to be reduced and the winch clutch engaged to make any towline changes.

Winches have predominantly been hydraulic, utilising the high-torque, low-speed functionality. Hydraulics have a natural in-built timeless load limit, providing a compact, simple, controllable and internationally accepted historical drive solution.

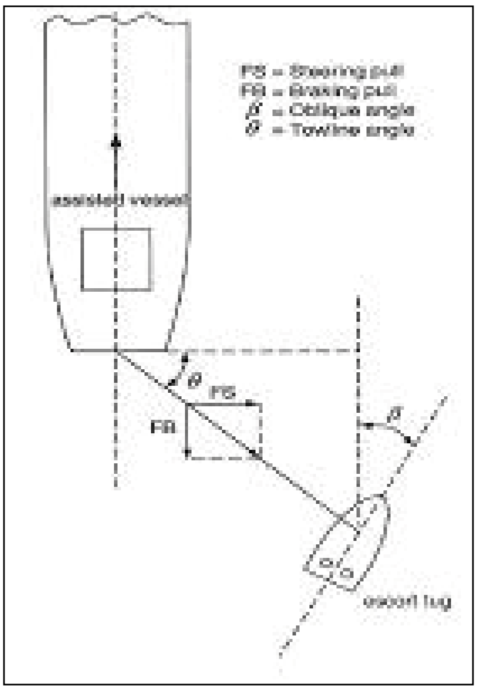


Figure 1: Simple tug towing winch (courtesy of MacGregor Plimsoll).

ESCORT TUG AUTHORITY DEFINITIONS

After the grounding of ***Exxon Valdez*** in 1989, the escort tug was introduced in the 1990s to ensure the safe passage of oil tankers and gas carriers. Faster, difficult to navigate passages brought about the development of indirect towing methods. Now a tug, using a relatively short tow tether, provides steering and braking using the hull design to exert maximum load control.

The term 'escort service' includes steering, braking and otherwise controlling the assisted vessel. The steering force is provided by hydrodynamic forces acting on the tug's hull (see *DNV Rules for Classification of Ships, Tugs, Supply Vessels and other offshore/ harbour vessels, section 16, A 200 Definitions 201*).

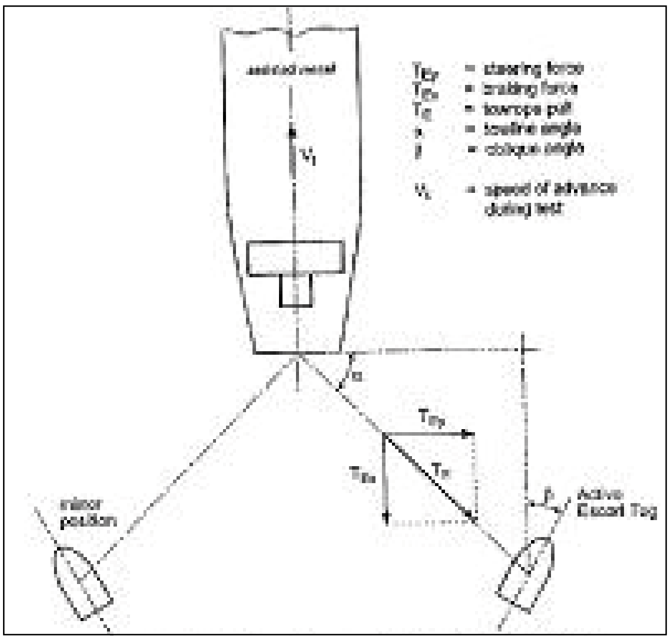


Figure 2: The escort service.

Figure 3: Typical escort tug operational attitude (courtesy of Robert Allen Associates).

The tug design uses the ship's propulsion in conjunction with the keel kedge to provide the manoeuvring force through the tow line and winch. To protect the escort tug from being overturned, the winch must be live and use a safe load control system. Certifying authorities have had to redefine the tow winch specifications to take into account the dangers of this operation.

- The towing winch has to have a load-reducing system in order to prevent overload caused by dynamic oscillation in the towing line;
- Normal escort operation is not to be based on the use of brakes on the towing winch;
- The towing winch must be able to pay out towing line if the pull exceeds 50 per cent of the breaking strength of the towing line.

This type of performance is not uncommon in hydraulics within the marine industry.

SIMPLE HYDRAULIC LOAD CONTROL

By setting a limit on the pressure in the hydraulic system, a load limit is set.

- Power = Force x Speed;
- Hydraulic pressure is Force;
- Flow is Speed;
- Pressure is limited by relief valve A;
- With a pulling force on the towline lower than the setting of A, the towline will be pulled in at a speed in relation to the design flow;
- A pulling force on the towline higher than the setting of A will pull the towline out at whatever speed is required to limit the load.

This load-control function provides a constant line tension.

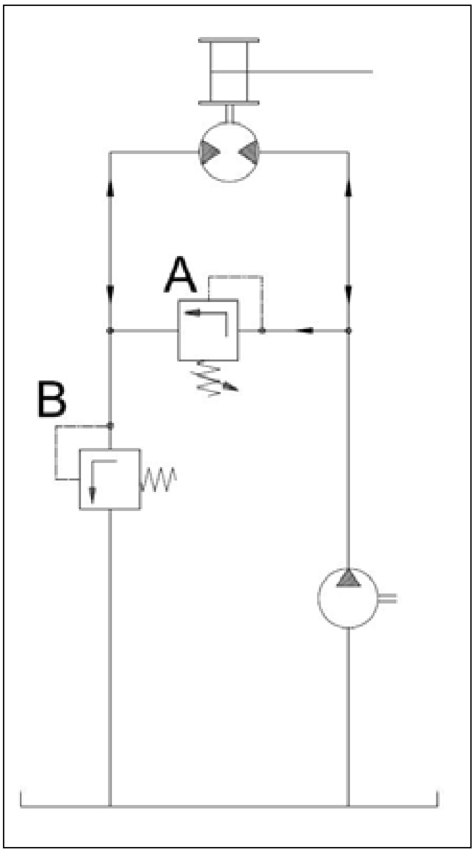


Figure 4: Simple load-control hydraulic circuit.

LOAD LIMIT AND CONSTANT TENSION APPLICATIONS

For more than 50 years this simple process has been used in various applications:

- Mooring winches for merchant and offshore;
- Autotrawl for fishing trawlers;
- RORO winches for merchant offloading.

FISHING AUTOTRAWL TENSION CONTROL

The traditional fishing method was to shoot the net, put on the brakes and tow. Fish swim horizontally so, as the vessel pitched on the waves, fish were missed. The most expensive fish swim near the sea bottom; if the net became caught, the only option was for the wire to break.

Towing the net live on the winch motors, rather than the brakes, produced a revelation in stern trawling. A pressure could be set that would hold and tow the net. As the vessel pitched on a wave, the additional force would allow the wire to be pulled out. As the vessel came down on the wave, the wire would be pulled back in. Towing along the bottom, if the net became caught, the wire would be pulled out. The vessel bollard pull would be reduced and the winches would slowly pull the vessel towards the net and, as the angle changed, the net would become free.

With regard to stern trawling, fishing vessels are fully automated, with links to depth sounders, wire set length automatic control, net mouth opening measurements and logging functions. All control the winches by using simple pressure control interfaced with electronics.

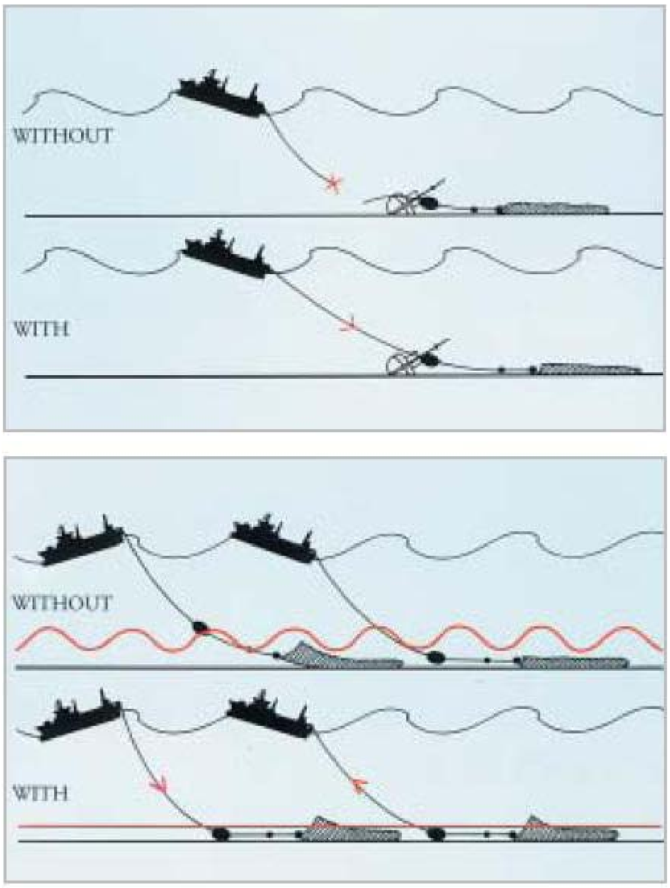


Figure 5: Autotrawl.

RORO JUMBO RAMP CONSTANT TENSION

- A 200-tonne ramp can cause quay damage;
- Winches with constant tension hold back 190 of the 200 tonnes;
- As the vessel is unloaded and the tide changes, the position compensates automatically;
- Highly technical efficiency is needed for accurate loads.

Figure 6: RORO jumbo ramps.

TELECOMMUNICATIONS CABLE BURIAL

- A plough is towed by the vessel;
- The tow rope force is held against the motor and relief valve;
- If the plough becomes stuck the tow rope will be pulled out, preventing damage to the plough;
- Constant tension is not used, only load limit.

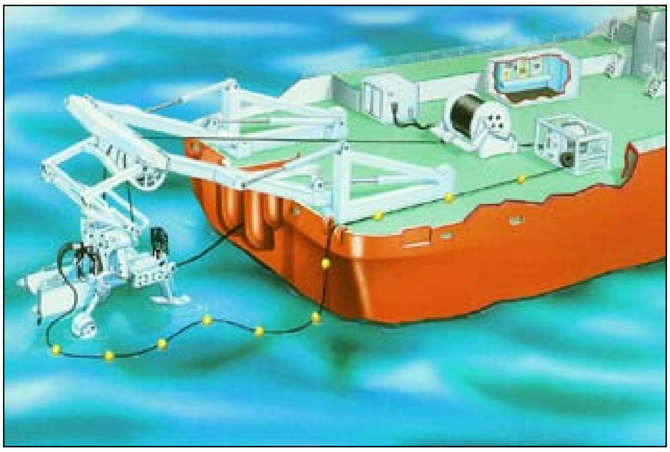


Figure 7: Telecommunications cable laying system (courtesy of SMD).

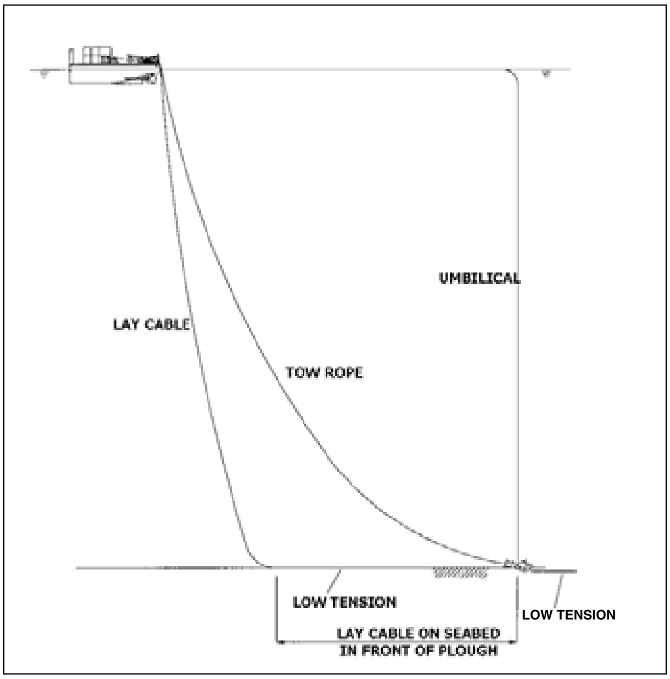


Figure 8: Sub-sea plough towing arrangement.

INERTIA AND LOAD LIMIT

- Drive system inertia is important to prevent expensive damage to the laying equipment at the point of overload.

Figure 9: Inertia comparison chart. See end of paper.

TYPICAL TUG TENSION CONTROL WINCH

The JonRie 250 series direct-drive hydraulic tension control winch gives the captain the facility to set the maximum tension.

Figure 10: Escort tug winch (courtesy of JonRie).

TENSION CONTROL WITH DEADBAND

In some applications, it can be preferable to be able to set a different heaving-in load to the pull-out load limit. This is called deadband. It can also reduce power consumption and heat.

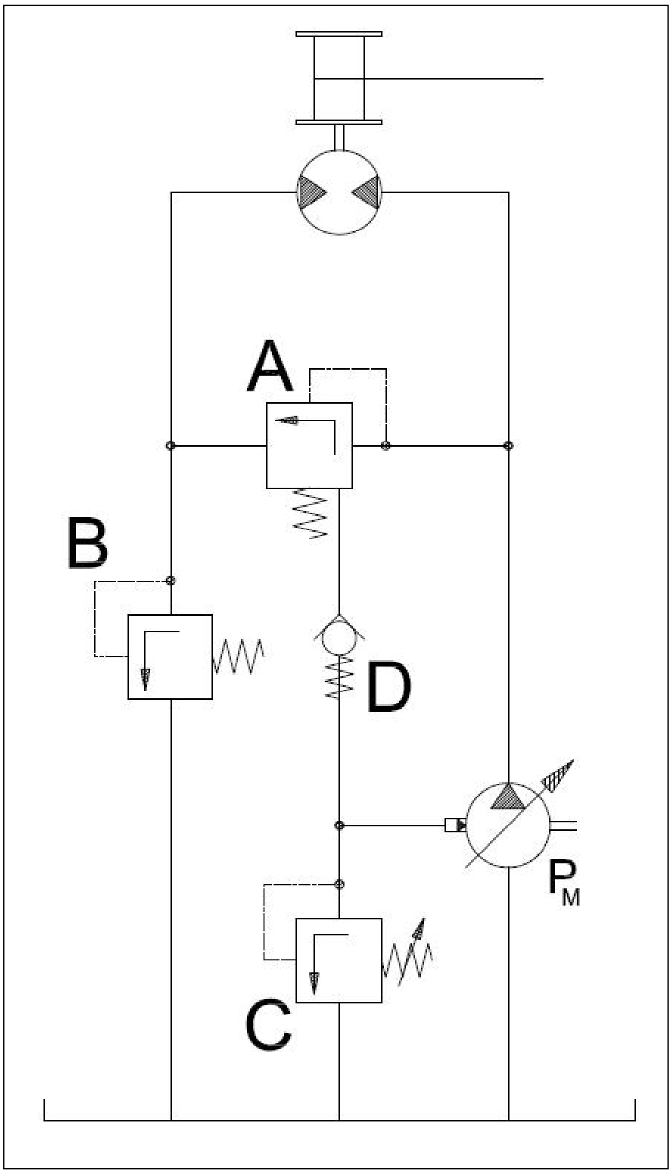


Figure 11: Simple load control circuit with deadband.

- Valve C is a remote adjustable control;
- The pressure compensating piston pump Pm will provide pressure up to the pressure setting of C;
- Valve D gives the difference between Pm heave in pressure and relief valve A pull-out load pressure;
- Valve C can be used to adjust towline length in a controlled manner by increasing the pressure capability;
- Load release can be achieved with valve C;
- D can be an adjustable valve to control the deadband;
- Using electronics to interface with these valves gives a fully flexible load control system.

EQUIPMENT SELECTION

Using this technique gives a completely new load function to the winch and drive system. The drive is now the connection between the tug engines and the load. The power that can be engaged can be high.

- The winch drive is now the connection between the full power of the tug engines and the vessel on tow;
- For the emergency release high speed and potential high power is required;
- Deck space is at a premium;
- Specifications and conditions can be variable.

HYDRAULIC MOTORS

These come in various types and sizes and, generally, have been quite low powered. This is because the market for hydraulics is generally low speed. Power is pressure multiplied by flow and the pressure is generally dictated by pipework specification. A motor that is designed to get a high flow through, which is the other power element to pressure, increases the physical size and therefore the cost.

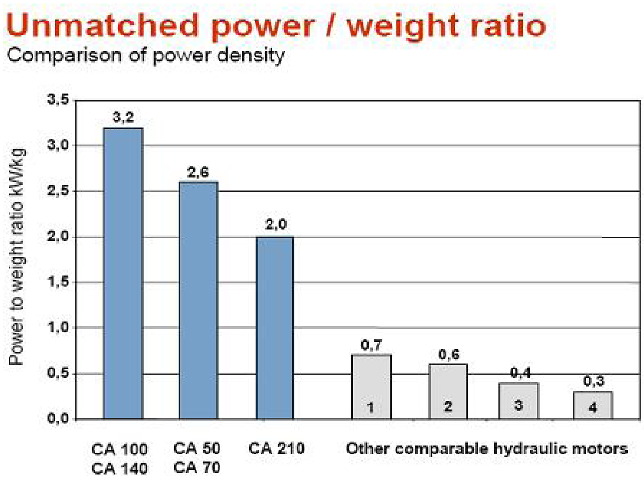


Figure 12: Power-to-weight ratio.

The development of radial piston cam curve motors for industrial drives has created a compact high power motor which uses four-port connection block technology, achieving a power-to-weight ratio of 3kW per kilogram.

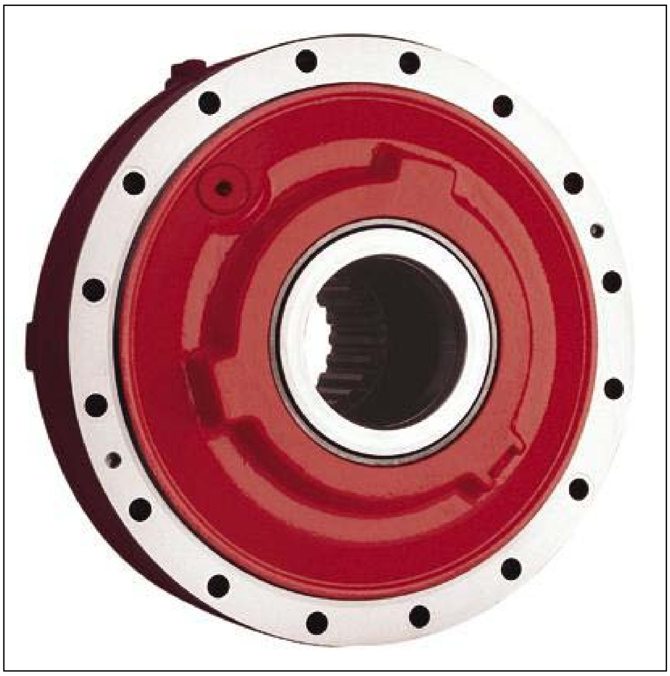


Figure 13: Hägglunds compact motor.

- Compact is a radial piston cam ring motor with a rotating hollow shaft;
- Introduced: 1994;
- Max torque: 73,000 nm;
- Speed range: up to 400 rev/min;
- Displacement: 1.2-13.2 lit/rev (26.4 lit/rev in tandem);
- The motor has an efficient design for high power constant tension drive. The port plate design allows for high acceleration load release functionality.

Figure 14: Hägglunds compact motor data. See end of paper.

- CA 100 at 200 rev/min has a flow capacity of 1,250 lpm;
- Uses four ports;
- 15-bar charge and 12-bar pressure drop;
- Power approximately 650kW continuous;
- Compact valves 1,000 lpm 350-bar.

Special valves are normally needed to handle these sorts of flow level. To complement the motors a range of standard flow and pressure control valves have been designed.

Figure 15: Hägglunds compact valves. See end of paper.

LNG ACTIVE ESCORT TUG

There is a system where, if the ship being towed creates overload, the VCTCA 1000 valve will open and the pump flow will be fed into the cooling loop.

Figure 16: LNG active escort tug hydraulic system. See end of paper.

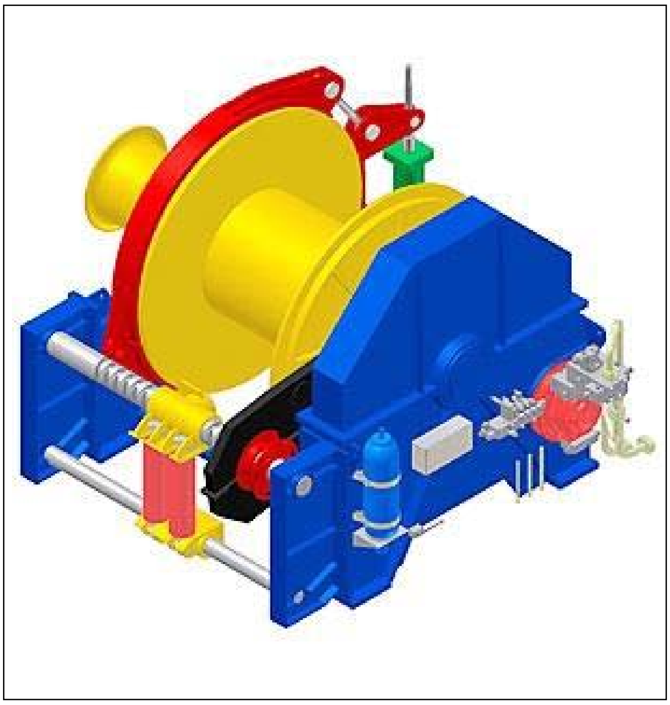


Figure 17: LNG active escort tug winch.

*Figure 18: LNG active escort tug **Romulo**.*

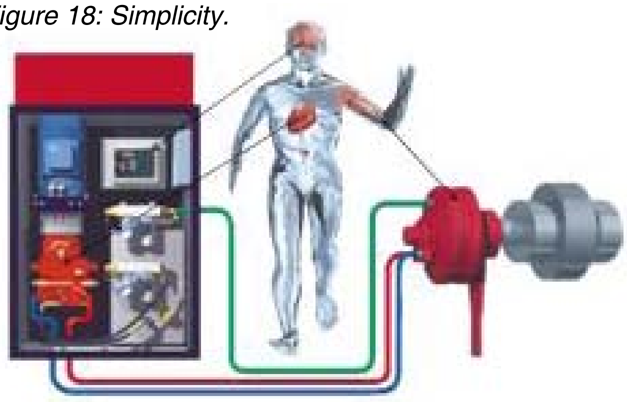
Here the vessel sets at a different angle, allowing maximum operation loads closer to the safety limits.

TRADITIONAL DRIVES

The traditional high-torque load-control drive system has always been used in hydraulics. An increase in available information and greater flexibility has promoted a move towards electric drives. The Compact high-flow design gives hydraulic drive systems greater application acceptability. The use of electronics to enhance the hydraulic strength and flexibility is a simpler solution.

Hydraulics is the muscle and electronics is the brain. Let us not confuse the issues.

Figure 18: Simplicity.



HYDRAULIC MARINE TRADITIONS

- Changing to complex drive systems to suit trends may not be necessary;
- The drive muscle exists;
- Environmentally acceptable fluids are available;
- Hydraulics can provide simple regenerative power;
- Using the latest electronics to enhance a traditional Marine Drive System could be more profitable.

Figure 9: Inertia comparison chart.

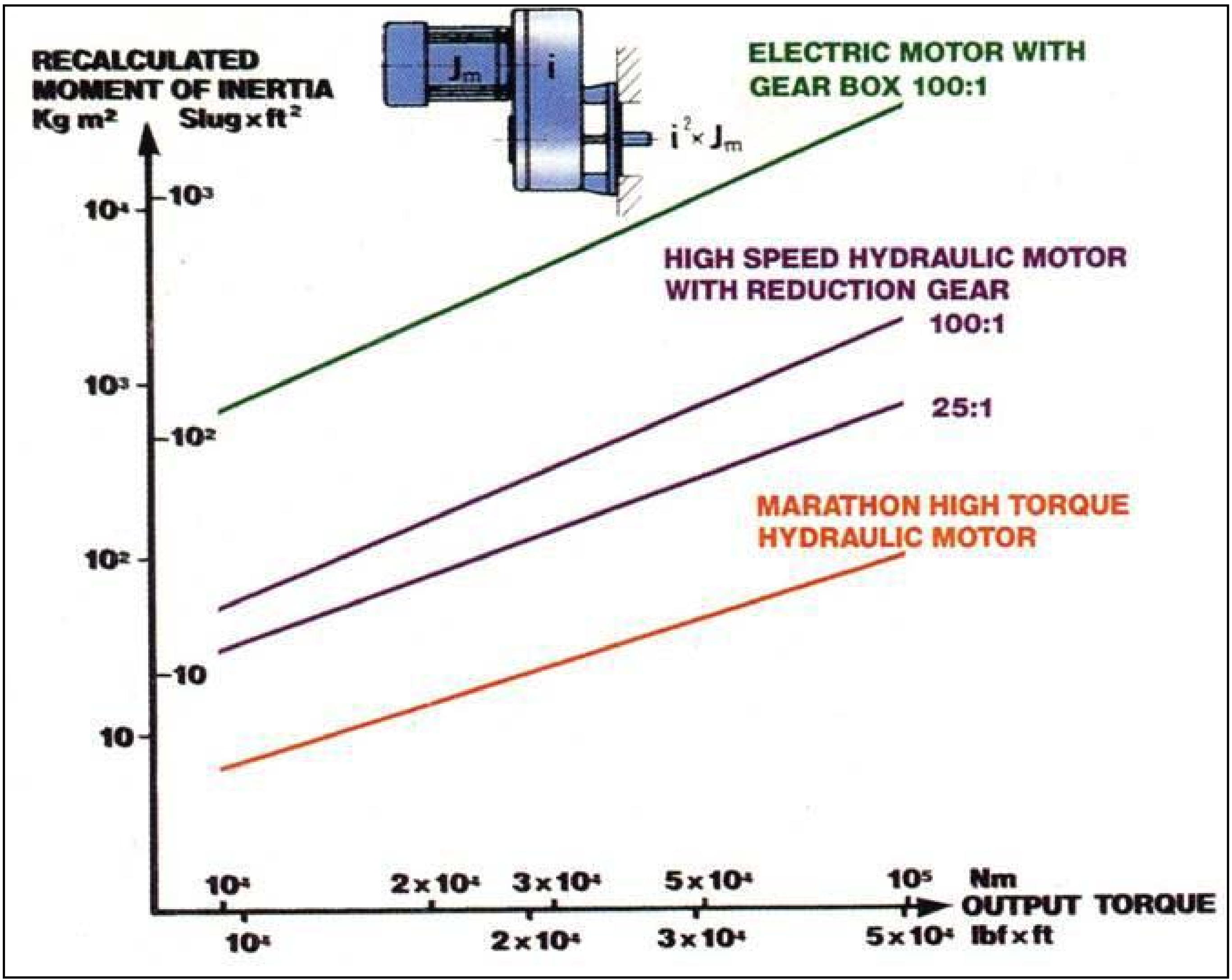


Figure 14: Hägglunds compact motor data.

Motor data										
	Full displacement					Displacement shift				
Motor-type*	Displace-ment (cm³/rev)	Specific torque (Nm/bar)	Rated speed** (rev/min)	Max. speed (rev/min)	Max. pressure (bar)***	Displace-ment (cm³/rev)	Specific torque (Nm/bar)	Rated speed** (rev/min)	Max speed (rev/min)	Ratio
CA 50 20	1256	20	400	400	350					
CA 50 25	1570	25	350	400	350					
CA 50 32	2010	32	280	400	350					
CA 50 40	2512	40	230	350	350					
CA 50	3140	50	200	280	350	1570	25	200	280	1:2
CA 70 40	2512	40	270	400	350					
CA 70 50	3140	50	225	320	350	1570	25	225	320	1:2
CA 70 60	3771	60	195	275	350	1886	30	195	275	1:2
CA 70	4400	70	180	240	350	2200	35	180	240	1:2
CA 100 40	2512	40	390	400	350					
CA 100 50	3140	50	320	400	350					
CA 100 64	4020	64	260	390	350					
CA 100 80	5024	80	220	310	350	2512	40	220	310	1:2
CA 100	6280	100	190	270	350	3140	50	190	270	1:2
CA 140 80	5024	80	245	340	350					
CA 140 100	6280	100	205	275	350	3140	50	205	275	1:2
CA 140 120	7543	120	180	245	350	3771	60	180	245	1:2
CA 140	8800	140	170	220	350	4400	70	170	220	1:2
CA 210 160	10051	160	105	150	350	5026	80	105	150	1:2
CA 210 180	11314	180	100	135	350	5675	90	100	135	1:2
CA 210	13200	210	85	115	350	6600	105	85	115	1:2

Figure 15: Hägglunds compact valves.

Figure 16: LNG active escort tug hydraulic system.