TECHNOLOGY TASK FORCE

Precision & Efficiency Gains from Secondary Controlled Hydraulic Circuits in the Offshore / Marine Environment

***As defined in NFPA's technology roadmaps, there are several machine-level technology trends that are actively shaping the future of the fluid power industry. One such area of development is the use and development of sensors in fluid power systems. To better inform and educate the market in these evolving technologies, NFPA is offering a series of resources focused on this topic*.**

In hydraulic engineering, the term "secondary control" has a distinct meaning - unlike primary controlled systems where a pump directly regulates flow and pressure, a secondary controlled hydraulic system utilizes a variable displacement hydraulic motor to perform these functions through torque. Secondary control solutions permit highly precise and dynamic control of actuators, offering benefits such as energy regeneration, enhanced efficiency, and excellent response time, making it a desirable solution for complex applications requiring exact motion control and power management. This article examines secondary control applications in hydraulics by using innovative motors, sensors, and responsive controls in demanding marine and offshore/subsea equipment.

Key Takeaways: Utilizing Secondary Controls in Hydraulic Systems

- **Secondary control shifts "control" from the pump to the actuator (motor).** Instead of a pump dictating flow/pressure, a variable-displacement hydraulic motor regulates speed/torque/position locally. This enables tighter, more dynamic closed-loop control at the load.
- **High-quality, fast sensors are the foundation for real-time performance (especially active heave compensation).** The featured use cases in this article repeatedly show that cable load, ship motion, slew/knuckle angles, and other extreme motion variables must be monitored quickly and accurately to generate stable commands in rough seas and environments.
- **Energy recovery and peak-power management**
- **Secondary control is most compelling where loads and directions change frequently.** Applications like winches, tensioners, cranes, slew drives, and motion-compensation systems benefit because they require bidirectional power flow, precise tension / torque holding, and rapid response to disturbances – sensors play a key role for constant monitoring of volatile conditions.
- **System success depends on integrating controls architecture (PLC/control system), sensors, and hydraulic hardware as one loop.** The examples emphasize that motors, sensors, controls / PLC, and energy-storage elements must be designed together to manage pressure, torque, flow, and regeneration reliably in demanding marine /

are major value drivers. Secondary units can regenerate power (motor acting as a pump) and, with accumulators, absorb rapid flow peaks and store / reuse energy. Using this method supports large installed-power reductions versus conventional hydraulic / electric drive approaches.

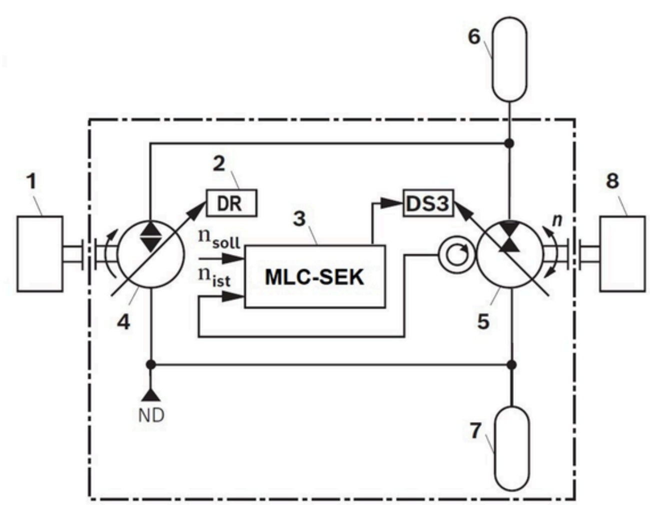
offshore environments.

- **Space savings and simplicity are an advantage of secondary control units.** These systems often eliminate the need for complex, bulky valve blocks, reducing the total space required for hydraulic components. In addition, tight working spaces benefit from a smaller operating unit.

What is secondary control in hydraulic motors?

For example, an axial piston secondary unit, applied in a constant tension or speed control circuit, is connected to a hydraulic power supply which provides constant operating pressure, and thus becomes the basis of an energy-saving drive concept. This achieves high dynamics in maintaining closed loop speed, position or torque control with energy recovery. Power consumption or energy regeneration is realized by matching demand with motor displacement and the prevailing load. The secondary unit controls the torque, not the flow. To lift or lower a load the secondary controlled unit must maintain torque by matching displacement to hold the load. If torque is greater, then the load lifts. And if torque is reduced, then the load lowers. An accumulator absorbs rapid flow peaks, and / or stored energy during lowering (the secondary unit becomes a pump) if the energy is not required by another actuator. Sensors continuously track cable load and ship movement, helping the system adjust the motors, control and the load in nearly real time.

Illustration #1 graphically represents a secondary unit circuit:



1	Drive	5	Secondary unit
2	Pressure controller	6	HP accumulator
3	Control electronics	7	LP accumulator
4	Primary unit	8	Output drive

Illustration #1 *(Source: Bosch Rexroth)*

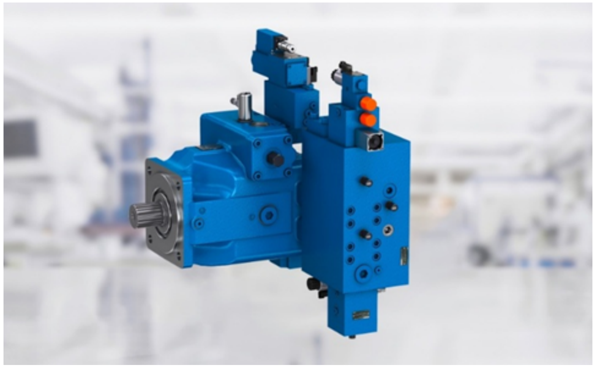


Illustration #2 Bosch Rexroth Secondary Unit; model A4VSG.DS3

What level of energy savings could be attained from secondary control technology?

For example, a 100-ton marine winch utilizing Bosch Rexroth's secondary control technology to achieve active heave compensation, attainable savings are shown in Illustration #3 below. This example is typical of conditions encountered in the North Sea. In the **Winch capacity (t)** column **(100)**, note the installed power **secondary control = 950 kW**, inclusive of energy recovery and hydraulic accumulator storage versus installed power with a **conventional hydraulic and electric drive** system = **3,600 kW.** This represents an approximate **70% reduction in energy** versus conventional drive solutions.

Winch capacity (t)	5	50	100	250	500
Installed power (kW)	55	480	950	2,350	4,700
Maximum power of winch (kW)	200	1,800	3,600	8,800	17,600
No. of drive units	2	6	12	14	28
Capacity of drive units (cm^3)	71	355	355	1,000	1,000

Wave amplitude: ±3m; Wave period: 9 sec; Hoisting speed: 30 m/min;
Maximum power of winch: AHC mode without additional hoisting movements

Illustration #3 Energy Savings from Secondary Control *(Source: Bosch Rexroth RE 08026/08.09)*

If secondary controlled drive systems appear more complex, should they be serviced more frequently?

Since factors such as oil cleanliness, oil quality, and operating/ambient temperatures prevent guarantees of a specific lifetime, the recommendation is to inspect the unit at 16,000 hours and continue intervals from there.

Is secondary control functionality limited within the marine environment?

No, secondary control has a variety of application opportunities within the marine sector, including:

- Heave compensation drives
- Winch drives
- Tensioner drives
- Shaft generator drives
- Slew drives

Secondary control technology also has opportunities in both Mobile and Industrial applications for a variety of functions:

- Test-stands (e.g. axle, gearbox, crash-test, torsional)
- Motion Simulators
- Transport / material handling
- Generator drives
- Saws, presses, grinding machines, mold oscillation and more

Watch this short testing demonstration video from Bosch Rexroth's secondary controls to simulate a vessel on rough seas.

The use cases below illustrate the wide variety of applications for secondary control technology:

Use Case #1: Knuckle Boom Cranes

Unlike stiff boom cranes, knuckle boom cranes excel in tight spaces as they can fold up tightly and have a high payload capacity that is ideal for mounted loading and offloading. They are also designed to deliver materials and place loads accurately, especially useful on marine vessels to provide lifting power around crowded decks. These cranes generally have a higher power demand during operation, which makes energy savings within secondary control systems an attractive option. The 150-ton crane features the following:

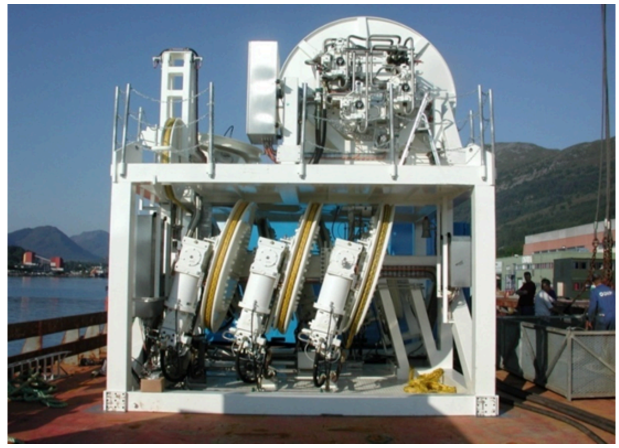
- Secondary controlled winch drive system
- 150-ton Main Winch with 12 Secondary Units, each 250cc displacement
- 20-ton Auxiliary Winch with 2 Secondary Units, each 250cc displacement

Source: Techano 150-ton Knuckle Boom Crane

This 40-ton knuckle boom crane is equipped with Bosch Rexroth active heave compensation. The motion sensor and control architecture communicates command signals automatically that correspond to the dynamic slew and knuckle angle data of current load positions.

Source: Lagendijk, Netherlands 40-ton Knuckle Boom Crane

Use Case #2: Deep Water Winch



These winches are specialized, robust lifting systems designed for high-load, long-distance cable deployment that feature large spool capacities. Their systems utilize both hydraulic and electric power with automatic level-wind systems, which guide cables back and forth across a spool or reel to ensure even distribution, and have high-tension capability. At undersea depths greater than 2,500 meters, conventional winch systems with the weight of steel cables will reach capacity limits.

Fiber ropes are lighter but are more difficult to handle - with secondary controlled drives, these handling problems were solved successfully.

Key Features:

- Fiber rope
- 50-ton load capacity
- Operation depth > 2,500 m

Source: Odim, Norway

Use Case #3: Stabilized Oil Platform

These specialized offshore structures are designed to maintain a stable position despite wind, wave, and water current forces. Two cranes on board serve for the transport of general supplies to-and-from cargo ships. Without active heave compensation, loading and unloading at sea would be exceedingly difficult - the lifting device is completely secondary controlled. The slewing device is also secondary controlled and additionally supported by a conventional hydrostatic drive.

Key Features:

- Heave compensation with overload protection
- Load capacity 5-ton
- Hoisting speed 100 meters/min

Source: Sevan Marine, Norway

Use Case #4: Subsea Crawler - Deep Sea Mining

Subsea crawlers are heavy-duty, remote-controlled robotic vehicles designed to operate on the ocean floor. These powerful machines utilize hydraulic suction or mechanical collectors to gather minerals, with ability to navigate a seabed of soft sediment by ensuring stability on uneven terrain. A retrofit added secondary control, improving underwater handling precision and dynamic response such as highly accurate path motions.

Source: De Beers, South Africa

Key Features:

- Secondary controlled chain drive
- Operation depth 200 meters
- 280-ton weight of vehicle
- Excellent track control

Summary

Secondary control in hydraulics represents a fundamental shift in how motion and force are managed: instead of relying on the pump to impose flow and pressure on the circuit. The secondary unit controls the torque by the variable displacement of the axial piston unit in a constant pressure system. This “control at the load” approach enables tighter closed-loop regulation of speed, torque, and position, which is especially valuable in marine and offshore systems where disturbances are constant, and operating conditions can change in seconds. **In practice, the performance of secondary control is inseparable from the performance of the sensor system.** Fast, accurate measurements, such as cable load and vessel motion, provide the real-time feedback needed to compute stable commands and maintain precise motion, including examples from Bosch Rexroth’s active heave compensation technology where timing and accuracy are critical.

Beyond controllability, secondary control delivers strong system-level benefits through energy recovery and peak-power management – a secondary unit can regenerate energy that would otherwise be dissipated. Secondary control technology is most compelling in applications that see frequent direction changes, variable loads, and the need for precise holding or tension control, such as winches, cranes, and stabilized-platform handling systems. Finally, successful deployment is not a component swap; it is an integrated design exercise. Hydraulic hardware, energy storage, the PLC / control architecture, and the system of sensors must be engineered as a single coordinated loop to manage pressure, torque, flow, and regeneration reliably. When these elements are designed together, secondary control becomes a practical path to higher precision, higher efficiency, and more resilient operation in harsh marine and offshore environments.

Want to know more?

Listen to NFPA's Fluid Power Forum podcast episode **"Conquering Our Mighty Seas: Modern Marine Motion Control"** featuring Jon Frey from Bosch Rexroth!

Author Acknowledgements

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Disclaimer: This resource is offered as an informational example of secondary controls and sensors in hydraulics. Reference to any specific commercial product, process, or service does not constitute or imply the endorsement, recommendation, or favoring by the National Fluid Power Association.

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