

Limitorque® Custom Quad-Yoke Actuator Offers Significant Size and Weight Savings to FPSOs

Abstract

Floating Production, Storage and Offloading (FPSO) units are offshore vessels used for the production and processing of hydrocarbons and oil storage. During the construction of a new FPSO, the installation of an emergency shutdown (ESD) valve was put on hold when it was discovered that there was insufficient space to accommodate the large, conventional actuator selected to operate it.

After a consultation with the customer, Flowserve Limitorque proposed a custom designed quad-yoke actuator capable of producing the necessary torque to work within the small footprint. This allowed the customer to install the ESD in the space allotted without costly and disruptive modifications, and without compromising the performance of the new ESD valve. This study details the development and implementation of the customized quad-yoke actuator.

Introduction

As an offshore processing plant and storage facility, space is a premium commodity on an FPSO. Usually, production modules on FPSOs are installed closely to each other, creating tight working environments. Because FPSOs bear refinery-grade heavy equipment on a marine vessel, managing weight translates directly into savings in capital expenditure investment evaluations. Lowering weight by just one tonne (2200 lb) can result in construction savings of \$30 000 to \$50 000.

On FPSOs, hydraulic actuators are preferred to pneumatics due to their smaller power cylinders. In the case of one enormous valve specified on this FPSO, however, conventional hydraulic actuators were too large for the available space.

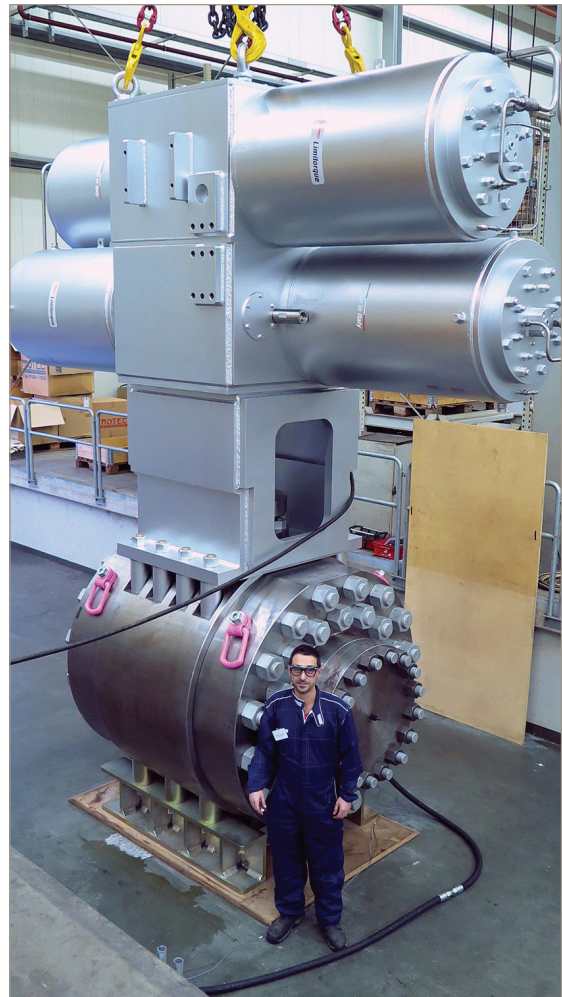


Figure 1: This custom actuator design by Limitorque saved at least 2 m (6.6 ft) and 2000 kg (4400 lb) over the originally specified unit and resulted in significant construction cost savings.

Custom Design Rationale

Situation: Size and Weight of Conventional Actuators

For this FPSO, the builders specified a DN 50 (NPS 20), PN 420 (Class 2500) ESD valve from Argus™. The valve required fail-safe, spring-return automation with a spring end torque of 250 000 Nm (184 000 ft-lb). When the actuator was sized, the dimensional footprint turned out to be almost 2 meters (6.6 ft) longer than for what the vessel layout plan had called. In such cases where space is a constraint, the conventional response is to turn to helical spline actuators. However, helical actuators are much heavier in comparison to Scotch yoke configurations.

A Custom-Designed Alternative

Flowserve Limitorque proposed a different approach: a custom-engineered layout. Limitorque R&D engineers designed an innovative quad-yoke system consisting of two dual-yoke mechanisms. This solution permitted a significant torque multiplying factor in a very limited horizontal displacement.

The final design was code named “Margherita” (the Italian word for “daisy”) based on the shape of the quad-yoke mechanism.

Design Challenges

The design challenges involved ensuring the mechanical efficiency of the system and the precise synchronicity of the quad-yoke mechanism. To further reduce the critical horizontal dimension of the actuator, the hydraulic power cylinders were installed within the coil of the fail-action springs.

The quad-yoke configuration was extensively modeled and validated through FEA before being released for construction, and the completed actuator was accurately tested for torque and performance to ensure compliance to expected and required operational criteria.

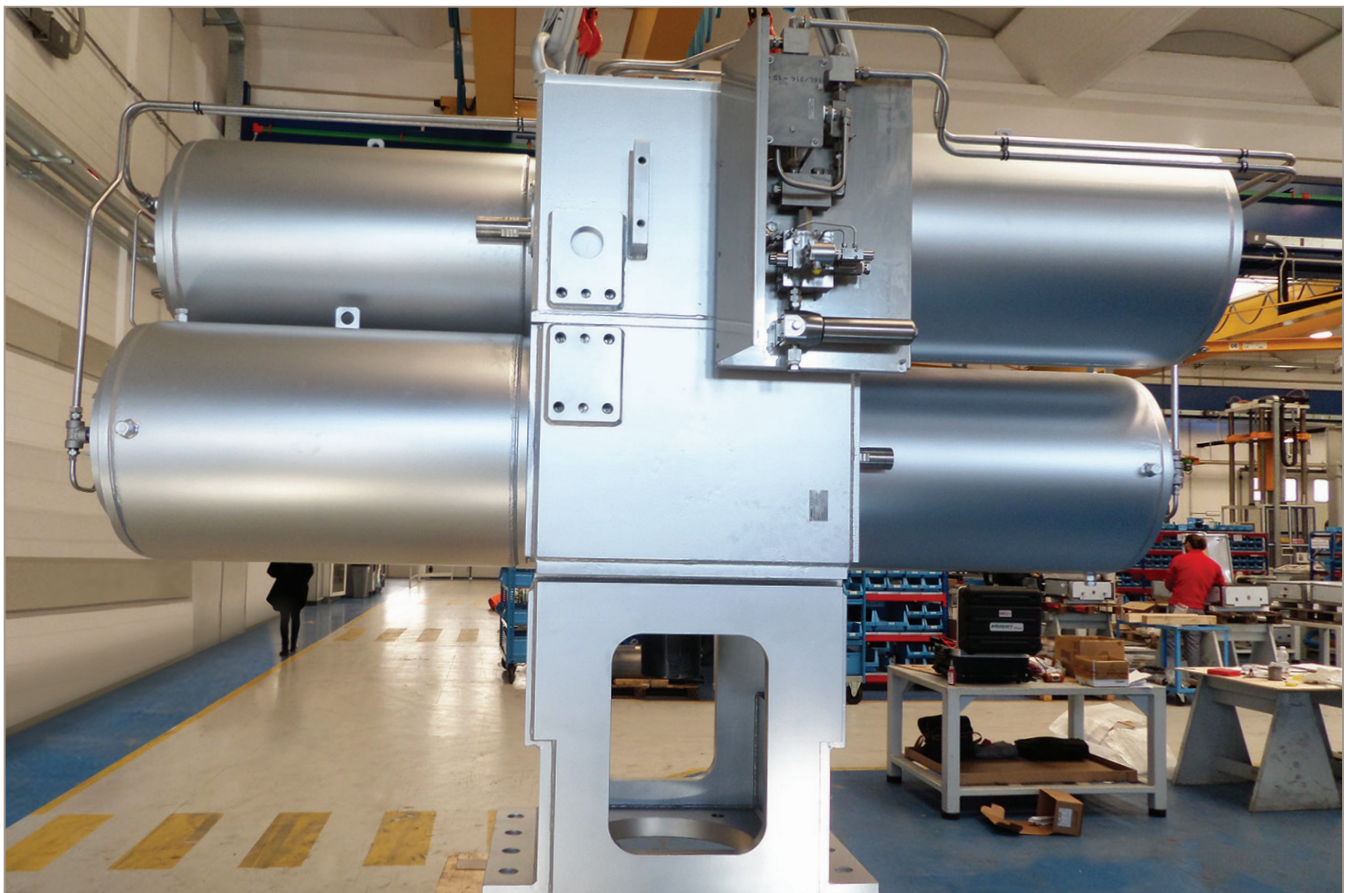


Figure 2: The innovative quad-yoke design permitted significant torque multiplying factor in a very limited horizontal displacement.

Implementation

The overall design allowed construction of the FPSO to proceed according to the originally planned layouts, with no need for costly and invasive redesign. The Limitorque quad-yoke actuator solution also ended up weighing approximately 2000 kg (4400 lb) less than competing helical mechanism actuators. Considering the significant cost-to-weight relationship of installed topsides on offshore facilities, this innovative design from Limitorque not only satisfied the customer's performance requirements, but also helped in realizing significant construction cost savings.

Conclusion

The effort to custom design an actuator to work within tight space and weight restrictions demonstrates the capability of Limitorque to respond to critical customer needs, with unique and efficient solutions that combine technical excellence with economic practicality.

The custom-engineered Margherita solution revealed itself to be sufficiently innovative for immediate patenting, providing a new turnkey actuator solution where size and weight are critical considerations.



Figure 3: Typical FPSO

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