

# Challenges of Revamping Leixoes Oil Terminal, Portugal

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*The most challenging type of project for any Engineering Consultancy is the design and construction of new projects within the boundaries of existing infrastructures. An example of this is the revamping of an operational Marine Oil Terminal with the latest state of the art loading technology while focusing on improving operational efficiency, minimizing the project schedule and optimizing costs for the client. In 2006, ILF Consulting Engineers of Munich, Germany was awarded the contract for the revamping of the Leixoes Oil Terminal, Porto, Portugal by GALP Energie.*

## Leixoes Oil Terminal operated by GALP Energie

GALP Energie is a Portuguese based, vertically integrated energy company which operates the two refineries of Sines and Porto. Leixoes Oil Terminal is the main import/export route for the Refinery of Porto handling 9 million Tons of product a year. The harbor infrastructure was originally built in 1890s. This was further extended to include 3 Berths and related facilities in 1967 when the refinery was constructed. The terminal is located approximately 3 Km from the refinery and connected by 17 pipelines for the transportation of various products.

As a result of GALPs strategic capital investment program to upgrade the production capacity and efficiencies of the two refineries over the next 3 years, it was required to upgrade its transportation facilities. The project budget for revamping of Leixoes Oil Terminal was approximately €30 million.

## Engineering Scope of Work

GALP awarded ILF with the contract for the engineering of the project as a result of its excellent references for terminal projects.

The scope of work for revamping of the loading facilities in the terminal included the following:

- Basic Engineering Design
- Detailed Engineering Design
- Tendering and Contract Award of Equipment
- Tendering and Contract Award of Main Construction Contract
- Construction Supervision

## Operational Flexibility

The Leixoes Oil Terminal consists of three berths capable of mooring various sizes of tankers and handling various types of products.

- Berth A: 100,000dwt, Black Products, White Products
- Berth B: 30,000dwt, Black Products, White Products, Petrochemical Products, LPG, Lube Oil
- Berth C: 5,000dwt, White Products, Petrochemical Products, LPG, Lube Oil

Due to the range of products produced in the refinery it was important for GALP Logistics Department to have the following aspects included in the design of the new facilities to reduce transport costs:

- Charter a range of tanker sizes for high demand fuels
- Flexibility to load specialized products on Berth B or C
- Redundancy of Marine Loading Arms to reduce downtime of the Berths
- Loading and Unloading Capabilities

With approximately 30 products transported through the 17 loading lines, it was not possible to have a dedicated Marine Loading Arm (MLA) for each product due to the dimensions of each berth and also due to the required capital investment.

The solution developed by ILF in conjunction with GALP Operations was to split the products into six distinct product groups. These were:

- Black Products
- White Products
- Petrochemical Products

- LPG
- Lube Oil
- Vapour Recovery

A matrix of the 30 products was created and an action defined for operations to follow when changing between products. This ensured the strict quality requirements of each product.

To further optimize the number of arms on Berth B and C, a common MLA was used for White Products and Petrochemical Products with isolation between each product group but the option to change groups depending on the logistical requirements. This flexibility also gave redundancy if required.

A vapour recovery MLA was also included in the design for each berth for the future implementation of a Volatile Organic Compound (VOC) handling system. The final number of arms for the three berths was 17 MLAs for products and 3 MLAs for vapour recovery as outlined in **Table 1**.

## Reinjection System

To reduce the amount of waste product after completion of the loading process, a Reinjection System was developed by ILF in conjunction with GALP Operations. After loading or unloading, the product present in the inboard of the MLA was reinjected back into the product line. This action greatly reduced the volume of product entering the slop tank on the berths. The system has resulted in energy savings for GALP because normally the reinjected product would have been pumped to the refinery for costly reprocessing. The Reinjection System consisted of a reinjection pump for each product group and a complex series of valves to reinject the product into the line from which it originated.

## Marine Loading Arms

The MLAs were specified in accordance with the OCIMF standard and were fitted with the latest available technology in Emergency Release Systems (ERS). The design philosophy of the loading arms was to have three alarm stages should the tanker start to drift from its original position during loading.

- The first stage was a warning alarm which informed the operator that the ship was starting to drift.
- If the operator did not correct the problem on time and the tanker continued to drift until the second stage alarm, then an Emergency Shut Down (ESD) of the Berth was activated. This automatically stopped the loading process in 5 seconds.
- If the tanker continued to drift until the third alarm (a distance of 3.5 m on Berth A) then the ERS was activated. The ERS system consisted of two valves on the loading arm which automatically closed in approximately 2 seconds followed by a safe disconnection of the arm from the tanker.

### Transient Hydraulic Model

A complex transient hydraulic model of the 17 loading lines from the refinery tank farms to the berths was completed, in order to calculate the Joukovsky surge pressure caused by an ERS or ESD action for various loading cases. To ensure that the pressure did not exceed the maximum allowable pressure of the existing loading lines, a surge protection system was installed on the berths. All MLAs had a surge relief valve which connected to a relief line. The relief lines from each berth were connected to an atmospheric relief tank located in the terminal. The ESD of the berth also resulted in the automatic tripping of the operating pumps in the refinery.

### Control System

The original design of the terminal in 1967 was with manual operated valves to control

**Table 1:** Marine Loading Arm – Design Details

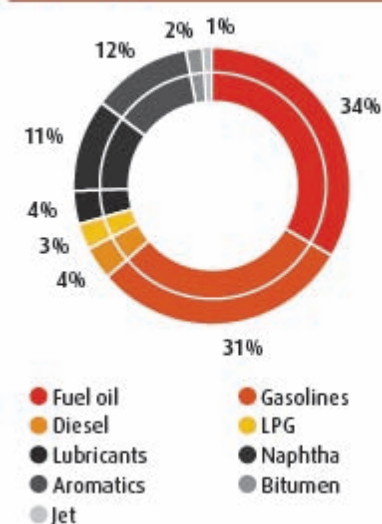
Berth	Arm No.	Product	Arm Dia (inch)	Design Temperature min/max	Design Pressure min/max (bar g)	Arm Operation per Berth												
						Connection Combinations												
						Single	1	2	3	4	5	6	7	8				
A	A1	Black	12"	-15° / +90°C	-0,5/+19,5	◆		◆	◆	◆								
	A2	Black	12"	-15° / +90°C	-0,5/+19,5	◆	◆		◆	◆								
	A3	Black	12"	-15° / +90°C	-0,5/+19,5	◆	◆	◆		◆								
	A4	VRU	12"	-15° / +90°C	-0,5/+19,5	◆	◆	◆	◆		◆	◆						
	A5	White	10"	-15° / +50°C	-0,5/+19,5	◆				◆		◆						
	A6	White	10"	-15° / +50°C	-0,5/+19,5	◆				◆	◆							
B	B1	Black	10"	-15° / +90°C	-0,5/+19,5	◆		◆	◆									
	B2	Black	10"	-15° / +90°C	-0,5/+19,5	◆	◆		◆									
	B3	VRU	12"	-15° / +90°C	-0,5/+19,5	◆	◆	◆		◆	◆	◆						
	B4	White or Chemical	10"	-15° / +50°C	-0,5/+19,5	◆			◆		◆	◆						
	B5	White or Chemical	10"	-15° / +50°C	-0,5/+19,5	◆			◆	◆		◆						
	B6	White or Chemical	10"	-15° / +50°C	-0,5/+19,5	◆			◆	◆	◆							
	B7	Lube	6"	-15° / +50°C	-0,5/+19,5	◆												
	B8	LPG	6"	-42° / +70°C	-0,5/+40,0	◆												
C	C1	White or Chemical	8"	-15° / +50°C	-0,5/+19,5	◆		◆	◆	◆								
	C2	White or Chemical	8"	-15° / +50°C	-0,5/+19,5	◆	◆		◆	◆								
	C3	White or Chemical	8"	-15° / +50°C	-0,5/+19,5	◆	◆	◆		◆								
	C4	VRU	8"	-15° / +90°C	-0,5/+19,5	◆	◆	◆	◆									
	C5	Lube	6"	-15° / +50°C	-0,5/+19,5	◆												
	C6	LPG	6"	-42° / +70°C	-0,5/+40,0	◆												

the loading process. Included in the revamping project was the installation of a new control system consisting of a central control room for the terminal. The operator on each berth also had access to the control system.

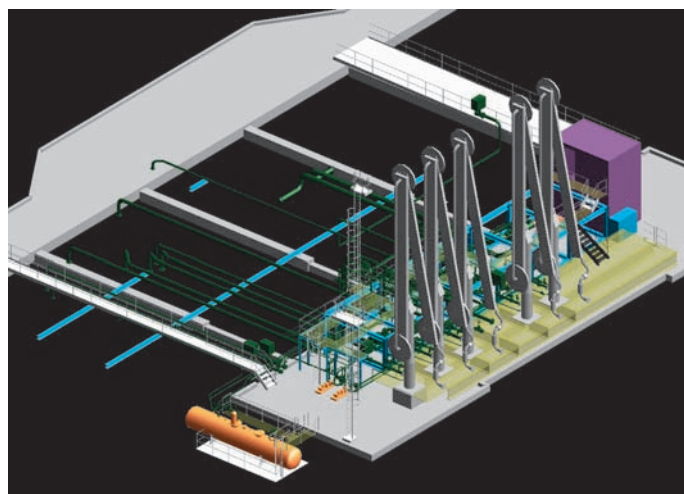
From the central control room or the berth, the operator could:

- Monitor the position of the loading arms relative to the alarm stages,
- Monitor the process conditions

**Exports by product in 2008**



**Fig. 1:** Refined products exported by GALP



**Fig. 2:** ILF IDOM Model of Berth C using PDMS

- Open and close valves from the control room

A new electrical system for the terminal was completed by GALP in advance of the construction works as a result of revamping the berths.

## Civil Issues

The original design of the berths consisted of two concrete caissons on the sea bed connected with a reinforced concrete bridge. The first problem was that the reinforced bridge was not designed in 1967, for the bending moments that would be exerted from modern loading arms. Two options were investigated to solve the problem

- Replace the concrete bridge between the caissons with a new design capable of handling the bending moments
- Install a metal bridge structure over the existing slab that would transfer the bending moments to the caissons.

After careful review of the options it was decided that a metal bridge structure anchored in the caissons was the best solution for the following reason:

- Reduction in the construction schedule
- Reduced construction cost

One disadvantage of the metal structure was the increased risk of corrosion over the design life of the project due to the exposed locations of the berths. This problem was addressed by selection of the correct paint specification.

In order to anchor the metal structure, it was required to verify the type of the concrete used in the 1967 construction of the caissons. This was completed by taking 3m core samples at strategic locations on the caissons. Based on the result of the concrete testing, the anchoring system to fix the structure to the caissons was designed.

## Project Procurement

Following the completion of the Basic Engineering in 2007, ILF and their local partner IDOM Portugal completed the Detailed Engineering Design. Due to the large quantity of valves and piping to be constructed on each berth, CAE software was used to build a detailed model of the new berths in order to optimize the layouts. Berth C had approximately 200 valves installed in an area of 8 m X 20 m.

The procurement was split into four main packages which were tendered on the market. The packages consisted of the following:

- Marine Loading Arms
- Automated and Manual Valves
- Surge Relief Valves



Fig. 3: Berth C - View from the Sea

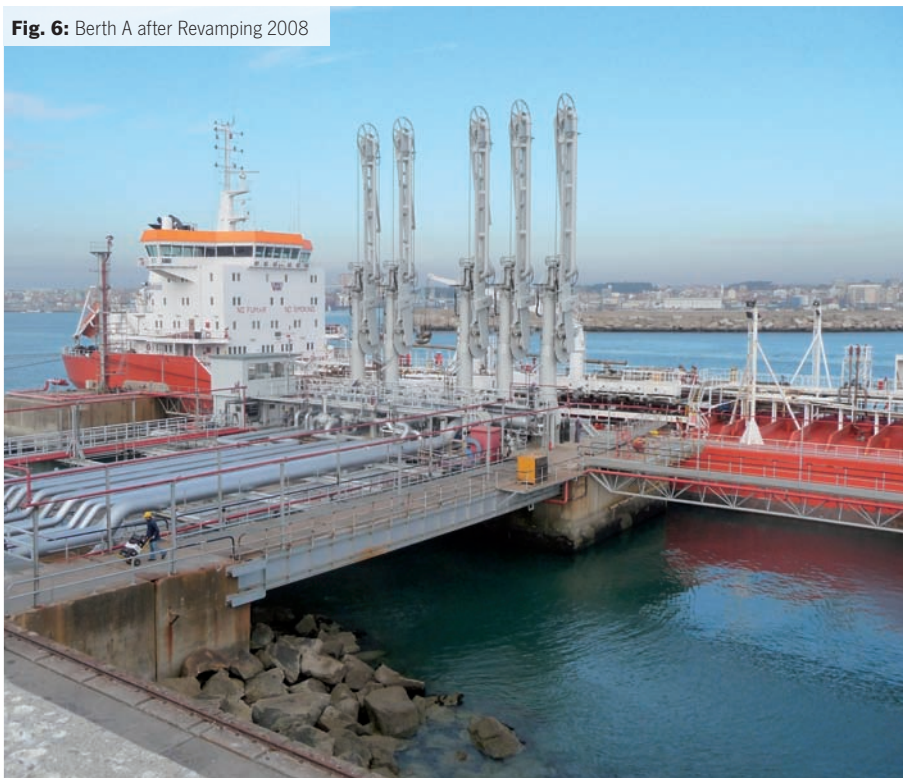


Fig. 4: Berth C - Piping and Valves



Fig. 5: Construction of Leixoes Oil Terminal 1967

Fig. 6: Berth A after Revamping 2008



- Main Construction Contract
- SCADA Package

The Main Construction Contract was tendered on the Portuguese Market. The main activities for the construction contractor were the following:

- Dismantling of Existing Loading Facilities on each berth which involved about 200 tons of steel per berth that had to be removed by floating crane to the port.
- Civil works to renew the working surface of the existing berths.
- Fabrication and Installation of the steel structures required to support the MLAs.
- Installation of the MLA on each berth with a floating barge crane.
- Fabrication of the piping
- Installation of the valves, piping and other equipment.
- Procurement and installation of the electrical / instrumentation components.
- Pre-commissioning of equipment.

**Project Schedule**

The project schedule was developed in conjunction with GALP to ensure the minimum interruptions to the refinery. The terminal is a strategic asset for GALP for the import and export of products to the refinery. In addition a Single Point Mooring (SPM) is also available for the discharging of crude oil into the refinery. It was therefore necessary for GALP to ensure that when one berth was taken out of service it would have the minimal impact on the production planning of the refinery.

During certain periods of the year the SPM cannot be used due to the weather conditions and it was therefore necessary to ensure that Berth A was available as a back-up of the SPM during the winter months. The summer period was therefore the only window available for the construction of Berth A. The scheduled outage period of each berth was approximately 4 months. On this basis Berth A was planned to start on 1st July 2008.

Unlike Berth A, Berths B and C have the ability to load the full range of products produced in the refinery (Refer to **Figure 1**). For this reason, Berths B and C are critical to ensure the export of products. Berths B and C are also used to import LPG to the refinery. The strategy agreed with GALP was to complete Berth C in 2009 and Berth B in 2010, which would minimize the impact on the production planning.

**Construction**

One of the main challenges with the revamping of the berths was the fact that the termi-

Fig. 7: Construction of Berth B 1967



Fig. 8: Berth A before revamping 2006



nal was in operation during the construction activities. This resulted in the need for strict safety procedures and careful coordination between GALP Operations, the Main Contractor and the Port Authority. Transportation of the MLAs was completed by sea and a barge crane was present for the duration of the construction activities.

Berth A was handed over to the Main Construction Contractor on 1st July 2008 and the first tanker of the revamped berth was successfully loaded with Fuel on 22nd October 2008. This represented a total construction period of 3.5 months and an improvement of 2 weeks over the originally planned schedule.

Berth C was handed over to the Main Construction Contractor on 18th May 2009 and the first tanker discharged LPG on 12th August 2008. This represented a total construction period of only 3 months and an improvement of 3 weeks over the originally planned schedule.

The construction of Berth B is scheduled to start in March 2010. Berth B will represent

the greatest challenge of the three berths because it is technically more complex.

To date the project has been completed with no accident as a result of the strict HSE policy implemented by the Client and the Engineer.

### Summary

Following the successful completion of Berths A and C, GALP Logistics are satisfied with the improved facilities, which have offered increased flexibility, greater operational performance and improved safety. GALP are very pleased with the performance of the Engineer, who managed the project successfully from the Basic Design Stage until the commissioning and handover of the Berths. The success of the project could not have been achieved without the assistance of the GALP Engineering and Projects Department who guided the project.

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- Kazakhstan-China Crude Oil Pipeline, Phases I & II, 962 km / 778 km, 20 Mt/a / 10 Mt/a throughput
- Baku-Tblisi- Ceyhan Crude Oil Pipeline, Turkish Section, 1070 km, 50 Mt/a throughput

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