DESIGN AND CONSTRUCTION OF THE BALEARIC SUBMARINE PIPELINE

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1 Introduction/Background

Enagas is Spain's principal high pressure natural gas transport, regasification and storage company as well as being the government appointed technical operator of all of Spain's gas network consisting of more than 8000 km of high pressure gas pipelines and three LNG regasification plants.

Figure 1.01 Enagas' Gas Network

Enagas was established in March 1972 by the Ministry of Industry with the aim of creating a national gas pipeline network. In June 2000 in accordance with the de-regulation of the Spanish gas network, Enagas was named as Technical Operator of the gas network with overall responsibility to guarantee the continuity and security of natural gas supply and the efficient coordination between the points of entry, storage facilities and the transport and distribution infrastructure. As part of it's network expansion programme, Enagas successfully undertook the installation of a submarine pipeline linking the Spanish mainland to the Balearic Islands of Ibiza and Mallorca.

This pipeline was constructed in two distinct sections, the first linking the mainland from a point on Spain's eastern coast in the vicinity of Denia to the Island of Ibiza with an approximate length of 120 km and the second linking the Island of Ibiza to the Island of Mallorca with an approximate length of 150 km.

Figure 1.02 Balearic Submarine Pipeline

The overall construction project also includes a compressor station in Denia and control/regulating valve stations on each of the two islands. The principal design characteristics of the submarine pipelines are:

Diameter:	Constant internal diameter, nominal 20" pipeline
Total Length:	270 km
Max. Water Depth:	approx. 1000 m
Product:	Sales quality dry gas
Design Pressure:	225 barg
Maximum Design Temp	50 ^{0}C
Minimum Design Temp	-5 ^{0}C offshore linepipe/ -10 ^{0}C onshore linepipe
Corrosion Allowance:	None
Pipe Material Grades:	Offshore Linepipe: DNV SAWL 450 IFD Buckle Arrestor and Onshore Linepipe: DNV SAWL 450 IFD
Corrosion Coatings	Internal coating: Epoxy coating External coating: 3-Layer Polyethylene 3-Layer Polypropylene
Concrete Coating	Reinforced concrete coating, 40 to120 mm thick, with a density ranging from 2.240 to 3.040 Kg/m3
Sacrificial Anodes	Aluminium/Zinc/Indium Bracelet type

Basic and detailed design activities which included the selection of the offshore routes and the performance of environmental, seismic and metocean studies were carried out between 2004 and 2006. For the route selection, full multi phase AUV (Autonomous Underwater Vehicle) techniques were utilised to generate accurate seabed information to allow precise route optimization. Procurement of project materials and coating operations were carried out between 2006 and 2007. Construction activities commenced at the end of 2008 and were successfully concluded in June, 2009

Offshore pipeline installation was by conventional 3rd generation lay barge techniques. The maximum water depth of approximately 1000 m combined with the high submerged weight of the concrete coated pipe resulted in the installation being on the limit of this installation technique. For this reason in the deeper section of the route, supplementary tension was provided by "live anchors" or tugs attached to the laybarge.

The pipeline landfalls in Denia and Mallorca were constructed using conventional open cut dredging techniques to pre-excavate a trench into which the pipelines were subsequently installed. Due to the existing topographical conditions and environmental restrictions, the pipeline landfall in Ibiza was constructed using horizontal tunnelling techniques. Pipeline installation in the landfalls was by onshore winches which pulled the pipelines ashore from the lay vessel anchored near shore, into the pre-excavated trench or tunnel. Tie-ins between the landfall and offshore pipeline terminations were by surface welding techniques once having recovered the pipe ends to the surface using davits.

Other post lay project activities included ploughing of nearshore areas in Denia and Mallorca to increase onbottom stability and minimize the affect of local fishing activities and rock dumping of cable crossings (previously prepared by the installation of seabed mattresses) and pipe span rectification and finally pre-commissioning activities which included hydraulic pressure testing of the system.

Specific environmental and permit related problems which were overcome by the project included:

- Highly environmentally sensitive seagrass or “Posidonia” located along the nearshore pipeline routes affected pipeline route selection as well as the placement of laybarge anchors during construction.
- The presence of migratory routes for sea life such as whales, dolphins and loggerhead turtles required the intervention of marine biologist to ensure minimum project impact to the same.
- The possible presence archaeological artefacts in the coastal areas required the intervention of archaeologists to ensure minimum project impact to the same
- Tourist activities on the mainland and island beaches restricted the working window to non-summer months
- The presence of an international airport adjacent to the Mallorcan landfall required special permits to avoid both physical and radio/electrical interference to flight paths from construction activities
- The presence of highly strategic desalination plants adjacent to the Mallorcan and Ibizan landfalls required special permits and a high degree of coordination between the project and plant operators
- Heavy fishing activities in the area which utilize bottom trawling techniques, required coordination with fisherman during construction activities as well as long term agreements with local fishing organisations

The principal Project Contractors were :

- Saipem-FCC: Pipeline construction activities including pre and post lay activities such and dredging, ploughing and rockdumping
- JP Kenny: Basic and detailed engineering as well as construction supervision
- Heymo: Project “Director Facultativo” as well as design/construction supervision of onshore facilities
- SCI: Third party certifying authority for welding/ndt/hydrotesting activities
- Bureau Veritas: Third party design verification
- Inypsa: Environmental engineering

2 Project History

The various studies, considerations and decisions which formed part of the final authorization for the installation of the Balearic Submarine Pipeline were:

- Various conceptual studies were performed over the past 10 years to determine the technical and economic viability of the supply of natural gas to the Balearic Islands
- The supply of natural gas to the Balearic Islands was considered in the Electricity and Gas Sector Planning for the period 2.002 - 2.011, pending a final decision as to the technical solution (Regasification Plant vs Submarine Pipeline)
- A Cabinet of Ministers Agreement to supply natural gas through a gas pipeline to the Balearic Islands was reached in December 2003
- Authorization for the installation of the Balearic Submarine pipeline was given to Enagas in July 2004

Execution of the Balearic Project was in accordance with the following key dates:

- Basic Engineering Sept.03
- Detailed Engineering Sept.04
- Detailed Pipeline Route Survey Feb.05
- Linepipe Order Feb.06
- Construction Contract Award Jul.07
- Construction Schedule:
  - Engineering and Procedures Jul.2007
  - Landfall construction Oct.07
  - Pipeline laying Oct.08
  - Completion Jun.09.

The complete Infraestructure for the Supply of Gas to the Balearic Islands consists of:

- Montesa Compressor Station
- Montesa-Denia Gas pipeline
- Denia Compressor Station
- Denia Valve/Control Station
- West of Ibiza (WOI) Submarine Pipeline
- Ibiza Valve/Control/Metering Station
- East of Ibiza (EOI) Submarine Pipline
- Mallorca Valve/Control/Metering Station

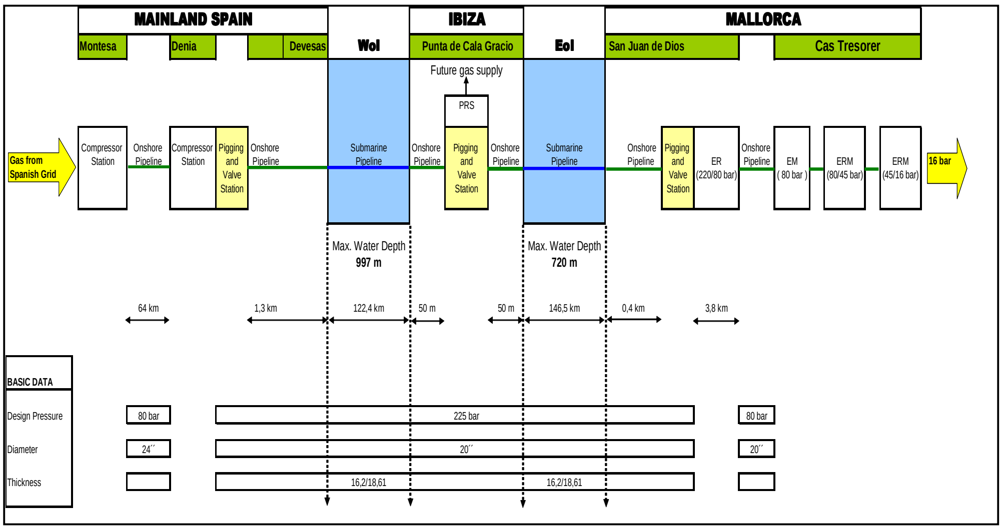

Figure 2.01 Complete Project Infrastructure

Only the Submarine pipelines, EOI and WOI, form part of this presentation.

3 Basic Engineering

Basic Engineering Studies were carried out by the engineering company JP Kenny commencing in September 2003. The main objectives of this phase of the work was to establish basic pipeline requirements and configuration as well as selecting the optimum pipeline landfall locations and submarine pipeline route.

In previous studies carried out for the Government of the Balearic Islands, different configurations for the pipeline and a number of potential landfall locations were identified on mainland Spain and on the Islands of Ibiza and Mallorca. Based on these previous studies, system requirements and the landfalls to be studied were defined.

a. System Definition

The pipeline system requirements defined from Basic Engineering studies were:

- East of Ibiza pipeline (EOI) – from a landfall on mainland Spain to a dual landfall on the island of Ibiza.
- Ibiza valve station and regulation station for local supply
- West of Ibiza pipeline (WOI) – from the dual landfall on the Island of Ibiza to a landfall on the Island of Mallorca.
- Mallorca valve station and regulation station for local supply.
- Based on the results of the preliminary hydraulic analysis, a pipe diameter of 20" was defined

b. Landfall and Pipeline Route Selection

The following considerations were taken into account in the selection of both the offshore pipeline routing and the landfall locations:

- Landfall permitting and authorisation constraints
- Preliminary safety and environmental considerations
- Consideration of the relatively high cost of the installation of a marine pipeline, compared to an onshore pipeline, thereby selecting a landfall location which kept the length of the marine pipeline to a minimum
- Onshore pipeline route from the landfall and consideration of tie-in to the onshore infrastructure
- Construction access for both onshore plant and equipment and marine vessels
- Feasibility of linking landfall locations to a practical offshore and onshore pipeline route
- Likely route preparation work (dredging at landfalls, nearshore pre-sweeping)
- Minimise length of landfall section of the pipeline
- Avoidance of Posidonia meadows
- Avoidance of fishing grounds
- Avoidance of shipping corridors and vessel anchorages
- Avoidance of military exclusion zones
- Avoidance of wrecks and seabed obstructions
- Avoidance of other offshore and subsea facilities
- Soil conditions along the pipeline route
- Seabed Slope Stability
- Currents
- Water depths
- Protection requirements against third party activities
- Minimisation of length and number of turn points
- Minimisation of seabed pre-lay and post-lay intervention requirements

Based on the results of the evaluation, the following landfall sites were selected, subject to further evaluation by survey and environmental evaluation.

- Playa Devesa, Denia - Mainland Spain
- Punta de Cala Gracio - Island of Ibiza
- San Juan de Dios - Island of Mallorca

A common characteristic of three landfalls was the reduced available space, due to the high tourist development.

Figure 3.01 Denia Landfall

Figure 3.02 Ibiza Landfall

Figure 3.03 Mallorca Landfall

Once the landfall locations were identified, a preliminary route for the WOI and EOI pipelines was defined, based on bathymetry studies previously performed by I.E.O. (Instituto Español de Oceanografía), with following characteristics:

- East of Ibiza pipeline (EOI) – from Denia on mainland Spain to a dual landfall at Cala Gració on the island of Ibiza, with a length of 118 km and a maximum water depth of 950 m.

Figure 3.04 WOI Pipeline Route

- West of Ibiza pipeline (WOI) – from the dual landfall at Cala Gración on the Island of Ibiza to San Juan de Dios on the Island of Mallorca, with a length of 145,8 km and a maximum water depth of 718 m.

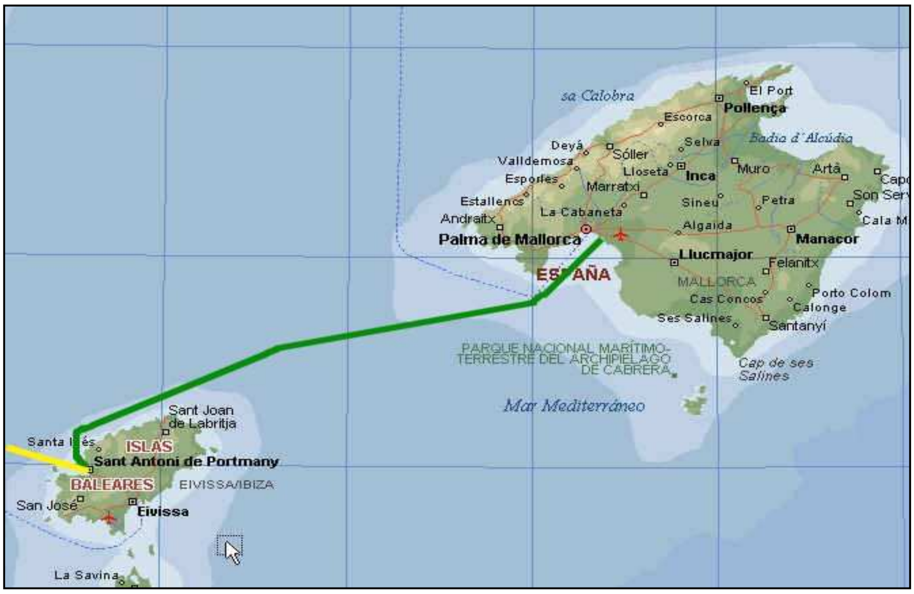

Figure 3.05 EOI Pipeline Route

c. **Pipeline Design**

The system was designed with a constant internal diameter and full bore valves to facilitate intelligent pigging.

Preliminary mechanical design (wall thickness, stability, crossing design) was performed in accordance with the Det Norske Veritas Offshore Standard DNV OS-F101 Submarine Pipeline Systems.

The wall thickness results indicated that a design pressure of 220 barg was the optimal in terms of nearshore pipeline steel wall i.e. there is no saving in steel wall thickness by reducing the design pressure.

A number of contractors capable of performing the pipelay, trenching, landfall, rockdumping, testing and pre-commissioning workscopes were contacted to obtain budget costs for the installation workscope and determine the requirements for vessel/plant and equipment.

4 Detailed Engineering

Detailed Engineering work was performed by the engineering company JP Kenny commencing in September, 2004. The main objectives of this phase of the work was to establish final pipeline requirements and configuration, carry out detailed route selection activities as well as the preparation of documentation required for the procurement of project materials and the award of the pipeline construction contract.

a. **Offshore Studies/Surveys**

The mechanical design of the pipeline was progressed in parallel with the offshore pipeline surveys. The offshore pipeline studies/surveys carried out to obtain sufficient detailed information and data to allow the detailed design included the following:

- Detailed Route Survey. Performed by Geoconsult AC in order to acquire, process, interpret and report on detailed hydrographic, geophysical and geotechnical data relating to the pipeline route in order to generate accurate Seabed DTM (Digital Terrain Model) to allow precise route optimization.
  This study identified two points which required important re-routing of the pipelines: a rocky area close to the Denia landfall and the platform of Ibiza slope with a narrow corridor available for pipe installation with a cable crossing.

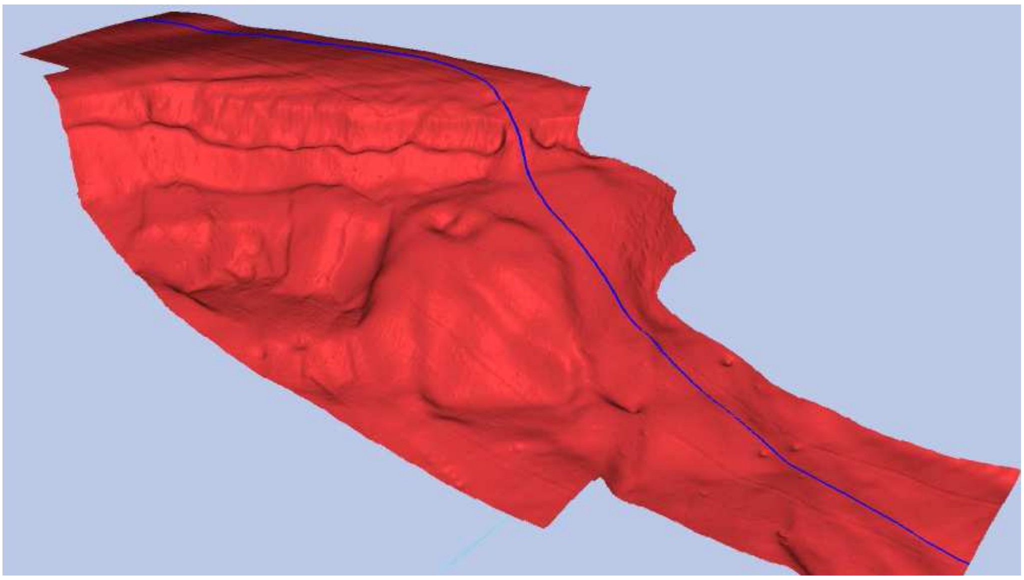

Figure 4.01 Seabed Model to Allow Precise Route Optimization Ibiza platform

- Landfall surveys. Performed by Geoconsult AC in order to provide sufficient detailed information to be used in the preparation of the detailed design and environmental impact studies for the project
- Metoceanographic Study. Performed by Proes Ingenierios Consultores, to provide detailed meteorological and oceanographic (metocean) design criteria along the pipeline.
- Sediment Transport Study. Performed by Proes Ingenierios Consultores to study sediment transport in the vicinity of the submarine pipeline with particular emphasis upon beach level changes at the landfalls, seabed mobility and trench/dredged channel backfill rates.
- Environmental Impact Study. Performed by INYPSA (Informes y Proyectos S.A.) to provide input to design and construction issues such as pipeline routing and reinstatement
- Seismic Study Performed by Principia Ingenierios Consultores S.A to quantify the seismic activity in the vicinity of the proposed pipelines route and to evaluate the risk and hazards to the proposed pipelines

b. Mechanical Design

The principal design code for the detailed mechanical design of the Balearic pipelines was DNV-OS-F101 which specifies the requirements for materials, manufacture, testing and documentation of linepipe.

The results of the design recommended the use of DNV OS-F101 450 grade linepipe with the following characteristics:

Pipeline Section	Recommended Wall Thickness	Constant Internal Diameter	Outer Diameter
EoI & WoI Offshore	18.6 mm	475.6 mm	512.8 mm
	16.2 mm	475.6 mm	508.0 mm
	18.6mm	475.6 mm	512.8 mm
EoI & WoI Buckle Arrestors and Onshore	37.4 mm	475.6 mm	550.4mm

c. On bottom Stability

The on-bottom stability of the Balearic pipelines was assessed in accordance with DNV RP E305. The stability analysis determined the pipeline concrete weight coat thickness requirements to ensure adequate lateral on-bottom stability during the pipeline installation period and during operation, resulting higher Concrete Weight Coating and density in nearshore sections.

d. Corrosion Protection

External corrosion protection of the pipeline is provided by a 3- PE external coating on the subsea section and a PP coating on the onshore section in Denia, close to Compressor Station with gas at high temperature.

Anode requirements were determined in accordance with the latest DNV code, DNV-RP-F103.

The cathodic protection of the onshore sections of pipeline was afforded through a combination of residual effects from the offshore system and by an onshore impressed current system from dedicated ground beds.

To reduce the gas flow friction with the pipe wall and to assist with pre-commissioning and pipeline cleanliness, an epoxy 'flow coat' was applied internally to each pipe joint.

e. Route selection and Span Analysis

In order to avoid excessive pipeline spanning and stress exceedances and thereby minimise pre and post-lay intervention works (such as rock dumping, peak shaving, sand bag placement and trenching) a number of changes were made to the pipeline routing from that originally proposed in the Basic Engineering phase. During each stage of the offshore pipeline route survey, bottom roughness analyses were performed and where necessary local re-routing of the pipeline was undertaken in order to avoid areas presenting significant spanning or stress problems. The span length analysis carried out to calculate the allowable freespan length limits was based on the Vortex Induced Vibration (VIV) onset avoidance criteria defined within DNV RP-F105. Installation, flooded, hydrotest and operating conditions were considered. In addition to technical criteria, a maximum span clearance of 0.35m was considered in order to avoid risk of trawl gear hooking.

Based on the above criteria, and considering environmental restrictions the final offshore routes were determined. These are presented in following figures

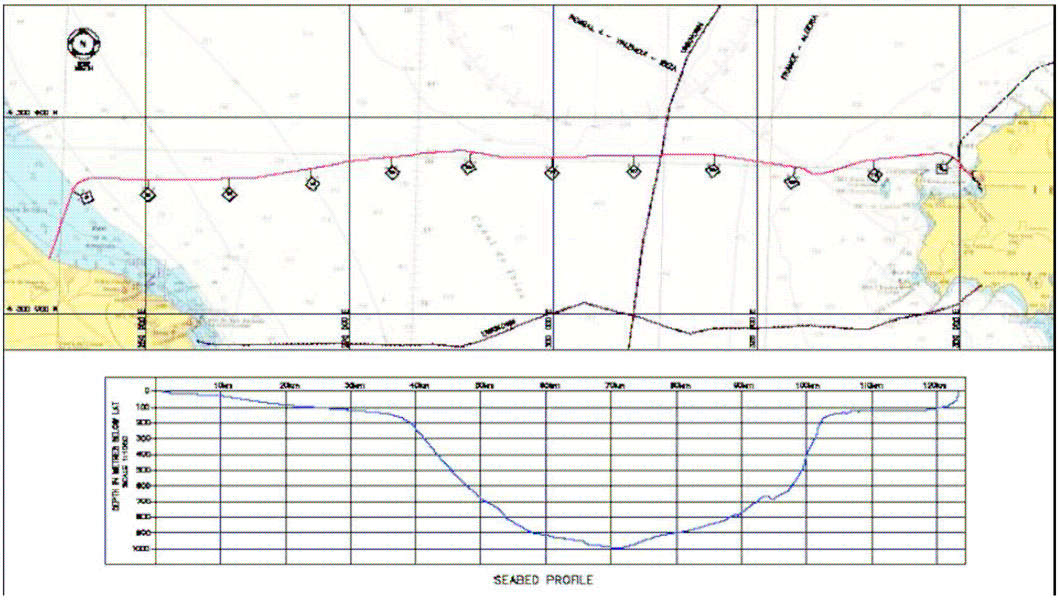

Figure 4.02 WOI Pipeline Route

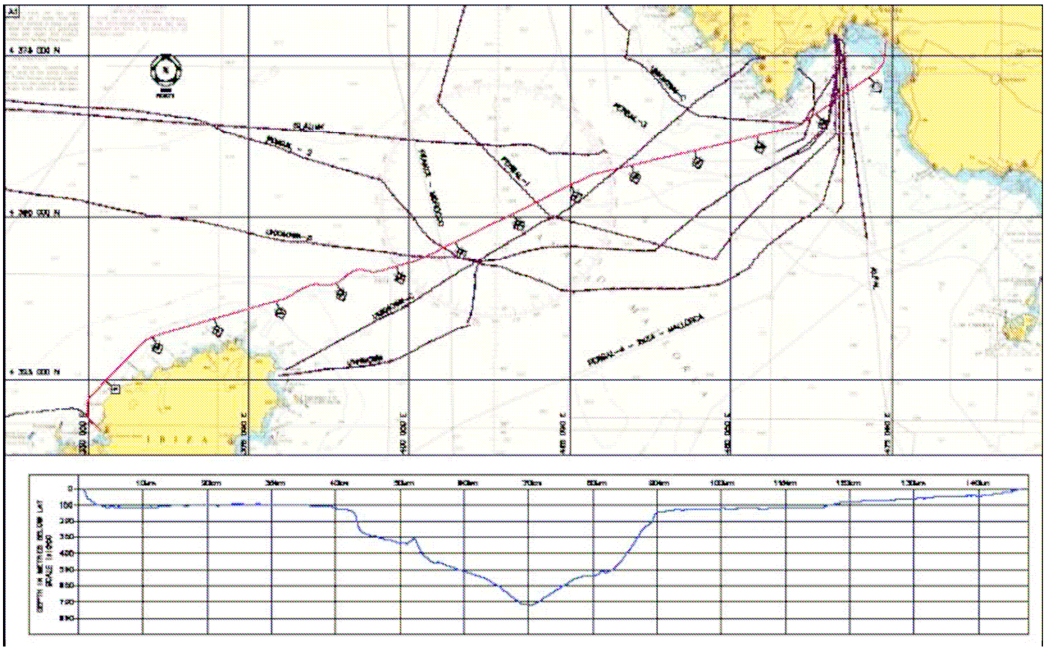

Figure 4.03 EOI Pipeline Route

f. Thermal Analysis

Thermal buckling analysis was performed to determine the susceptibility of the pipeline to thermal buckling, in particular due to the elevated temperature at Denia during operation (close to Compressor Station). The thermal buckling analysis considers lateral buckling and upheaval buckling scenarios. The results of the lateral buckling analysis show that lateral buckling is unlikely to occur due to route induced features such as bends. However a potential for lateral buckling remained, especially where third party interaction (fishing) occurs. Upheaval Buckling results indicated the minimum bend radius requirement of 300m applied over the entire pipeline route.

g. Seismic Analysis

The Seismic Hazard Evaluation study determined possible seismic triggered slope instability and displacement discontinuities of the seabed in the vicinity of the submarine. The results of this assessment indicated that the level of predicted seismic activity i.e. ground accelerations, within the general location of the proposed pipeline route and over the pipeline design life are low i.e. < 0.1g for a 475 year return period. Therefore the probability of a seismic event initiating liquefaction phenomena and leading to slope slippage or a seabed displacement discontinuity was considered very low. Further, it has been shown through analyses that if a slope slippage did occur the resulting buried pipeline lateral deformation would not exceed the design yield strength limits of the pipeline material. As a consequence, the vulnerability of the pipeline to slope slippage and/or seabed displacement discontinuities incidents was considered negligible.

h. Trawl Gear Interaction Analysis

For the submarine pipelines where trenching was not required to ensure on-bottom stability, analysis of trawl gear-pipeline interaction was carried out to:

- Assess the pipeline dent depth as a result of impact by trawl gear
- Determine the maximum stress in the pipeline due to trawl gear pull-over and carry out combined loading checks
- Assess the susceptibility of the pipeline to trawl gear hooking, define the maximum stress levels in the pipeline and carry out combined loading checks
- Define the maximum permissible span clearance to avoid trawl gear snagging.

The results of the dent depth calculations, based on a conservatively assumed bare pipe, indicate that the predicted dent depth as a result of trawl gear impact remained within allowable limits. As the pipeline will be concrete coated along its entire length, denting is not considered to present a concern to the submarine pipelines.

The pull-over analysis results indicated that the weight coat thickness, as determined in the on-bottom stability analysis report was adequate to resist pull-over loads along the majority of the pipeline route, where the pipeline is at ambient temperature. However, the warm section of the WOI, between the Denia landfall point and approximately KP 37, did not meet the combined loading criteria from trawl board pull-over. Therefore additional analyses were required for this section to assess the required minimum pipeline weight requirements to adequately resist pull-over forces. As a result of these additional analyses, an increased weight coating thickness was recommended in this area. The minimum required coating thickness increased from that defined by the Stability Analysis, as shown in the following table:

Location	**KP**		**CWC Thickness (mm)**	**CWC Density (kg/m^3)**
	From	**To**		
WoI	17,0	20,5	120	3040
	20,5	26,0	100	3040
	26,0	31,5	80	3040
	31,5	37,0	60	3040

The hooking of trawl boards and the release of the wedged trawl board by pulling of the warp line, and thus lifting the pipeline, was analyzed in order to confirm the integrity of the pipeline for this type of interaction.

The hooking analysis results indicated that if hooking occurred the pipeline was not susceptible to local buckling as combined loading criteria was not exceeded for either partial penetration or wedging of a trawl board under the pipeline. In the event that hooking did occur, it was proposed to apply a maximum allowable span clearance criterion for the submarine pipeline in order to limit the potential for trawl gear hooking. For typical trawl board dimensions used in Mediterranean waters, the critical span height to avoid trawl board wedging was found to be approximately 0.35m. In strict accordance with DNV Guideline No.13 , wedged hooking may in theory occur for spans exceeding 0.35m in height. Therefore, in order to avoid any such hooking, span correction was deemed to be required in case the span clearance exceeded such limit.

i. Installation Analysis

An installation analysis was performed to verify the layability of the 20-inch pipelines in the deep water sections for the selected pipeline parameters, such as pipe wall thickness and concrete thickness, in accordance with DNV OS-F-101 requirements.

The Installation Analysis considered pipeline installation following the S-lay method only, as this method (as opposed to the J-lay method) was considered governing with respect to pipe strains due to the presence of an overbend configuration. A 2-dimensional static analysis was carried out and as such was regarded as a preliminary installation analysis. The analyses was carried out using the pipeline installation simulation program OFFPIPE in accordance with DNV OS-F101 for the following cases:

- Pipelay analyses for base case pipeline, i.e., standard concrete coating applied along entire pipeline route
- Combined loading criteria and concrete crushing limit state checks for pipeline base case
- Analysis of additional cases were carried out to investigate the layability of pipelines using typical 3rd generation lay barges for optimised coating properties and removal of concrete weight coating in order to reduce the catenary weight

The results of the analysis indicated that in general the pipelines could be installed with the larger 3rd generation and 4th generation lay barges. The typical 3rd generation barges would only be able to install the pipelines to a limited water depth before the required tension levels could exceed the vessel capacity.

It was recommended that the selected pipeline installation contractor perform detailed installation analyses for their selected vessel and stinger configuration for all installation cases (including abandonment and recovery).

j. Fatigue Analysis

Pipeline Life Cycle Fatigue was performed to determine the fatigue usage levels for the submarine pipeline under pressure and temperature related cyclic loading. The aim of the design was to ensure that the pipeline had an adequate fatigue life according to the requirements defined in DNV-OS-F101, for all phases of the design life. The potential causes of pipeline fatigue considered were:

- Steel pipe fabrication process (mill test)
- Installation – Vessel motions and change in shape of the pipeline catenary and seabed/touchdown point interaction
- Vortex Induced Vibrations (VIV) induced by current and waves
- Hydrotesting
- Shutdowns during the design life
- Fluctuations in axial, hoop and bending stress due to operating pressure and temperature variations.

The analysis results presented showed that the fatigue usage was within the allowable design code limits, for the assumed loading cycles, using the S-N curve approach.

k. Scour and Sediment Transport

A Sediment Transport Study was carried out to determine sediment transport in the vicinity of the submarine pipeline with a particular emphasis upon:

- Beach level changes at the landfall
- Seabed mobility at landfalls; and
- Trench/dredged channel backfill rates.

It was noted that wave and current incidence, on the landfall beach at Denia, mainly occurred from a perpendicular direction, however normal wave heights within the surf zone were found to be moderate and seasonal sediment transfer was therefore predicted to be low. Storm events were however predicted to initiate a higher rate of sediment transport

There was no drifting sediment to be characterised at the Ibiza and Mallorca shoreline as the seabed surrounding these areas is primarily formed by rock.

Silting of the pre lay dredges and post lay trenches during the temporary construction phase was also assessed. The results for the Denia and Mallorca landfalls show that the backfill rate was highly dependent on seasonal changes in the environmental conditions and water depth. Predicted maximum dredge backfill rates at the Denia landfall during the winter season were quite high and would therefore require ongoing dredging to maintain the profile prior to pipelay.

l. Dredging and Trenching

The detailed design defined the requirement for pipeline burial and backfill cover at the nearshore Denia and Mallorca landfalls. This was achieved through pre-lay dredging and post-lay trenching of the pipeline.

Dredging, trenching and burial of the submarine pipeline was required at the nearshore Denia and Mallorca landfalls for the following reasons:

- Pipeline lateral stability protection from hydrodynamic loading in the shallow nearshore areas
- Protection from inshore recreational activities i.e. pleasure craft, bathers, scuba divers etc
- Prevention of pipeline lateral buckling arising from fishing trawl gear pullover loads (‘hot’ Denia landfall section only)
- Prevention of pipeline upheaval buckling arising from temperature driven effective axial compressive force in the pipeline combined with possible large seabed imperfections (‘hot’ Denia landfall section only)
- Minimising interaction with fishing gear from the mainly artisanal fishing fleet in shallow waters
- Provision of partial protection from nearshore vessel stranding and vessel anchors

The final pre-lay dredge, post lay trench and backfill requirements, encompassing all aspects of the pipeline detailed design, were defined as follows.

Location		Start KP	End KP	Length (km)	Minimum Trench Depth	Minimum Backfill Cover
Denia	Pre-lay Dredged Trench	0.990	2.600	1,610	3,0 m	3,0m
	Post-lay Ploughed Trench	2.600	17.070	14,470	0,50m	0,50m
Mallorca	Pre-lay Dredged Trench	145.500	146.390	0,890	1,5m	1,5m
	Post-lay Ploughed Trench	140.930	145.500	4,570	0,50m	0,5

m. Landfall Construction Requirements/Constraints/Methods

The landfall construction requirements and constraints were identified based on the Environmental Impact Assessment and through detailed evaluation of the features of the three landfalls considered, these being those selected in the Basic Engineering Studies:

- Denia (Mainland Spain)
- Punta de Cala Gracio (Ibiza)
- San Juan de Dios (Mallorca)

The conditions and restrictions present at each landfall were evaluated with respect to the following items:

- Temporary and permanent site layout
- Environment issues
- Local authority requirements

- Existing and planned infrastructure
- Military activity and ordnance
- Navigation
- Reinstatement.

Construction methods for each of the landfalls were evaluated considering the following issues:

- General description of landfall
- Geotechnical survey results
- Selection of landfall construction method
- Landfall constraints and requirements
- Landfall construction method
- Anticipated pull loads
- Shore approach routing
- Construction site

The conclusions of these evaluations at each of the three landfall was as follows:

- Denia: an open cut, (pre-lay dredged) construction method was selected. This method offered the lowest construction risk, combined with an acceptable environmental impact.
- Ibiza: a tunnelling landfall construction method was selected. This was due to the reduced environmental impact, the appropriate sub-bottom soils, the lower risk of disruption to the existing facilities as a result of potentially lower levels of vibration, reduced vehicle movements, reduced magnitude of required excavation, and less challenging reinstatement offered by this solution. Two tunnels were required one for the incoming WOI line from Denia and one for the outgoing EOI line to Mallorca.
- Mallorca: an open cut (pre-lay dredged) construction method was selected. Whilst the tunnelling option at this location could have been technically feasible from the ground conditions encountered, the length of tunnel required to preclude dredging through the Poseidonia and to completely mitigate the environmental impact was considered to result in unacceptably high risks as the required length was in excess of single “throw” tunneling operations carried out to date.

n. Rock Dumping

Rock dump requirements were determined at each of the live cable crossing locations, at the tunnel exit locations, at possible out of straightness locations and for the predicted freespan rectification locations. The rock dump construction was of a single layer construction in comparatively deep water, and a two layer design consisting of a filter layer covered with an external armour layer, for shallower water intervention locations.

- Four live cable crossings located in water depths greater than 77m which could be covered using filter grade rock only, without an exterior armour grade rock layer
- Three live cable crossings located in water depths of approximately 50 m, which may require a filter grade rock inner layer capped by an armour grade rock outer layer, to ensure stability over the pipeline design life
- The tunnel exits on to the seabed at Ibiza, to provide a smooth profile and protect against third party snagging, and to provide pipeline stability. As this exit point was predicted to be located in shallow water depths, both filter and armour grade rock layers would be required.
- Other locations along the pipeline route for cover of remedial works, such as supplementary trenching cover, disused cable end stabilisation, pipeline out of straightness below the minimum bend radius limits, rectification of excessive spans etc.

5 Material Procurement

Procurement of all principal materials required for the construction of the submarine pipeline was carried out by Enagas. This included the linepipe, anodes, anti-corrosion coating and concrete weight coating, as well as the valves, actuators, bends, etc required for the construction of the onshore valve stations. Quality control of all procurement activities was carried out by specialized third party inspection companies.

a. Linepipe

The linepipe for the Balearic Project was fabricated by ILVA-EEW in their fabrication plants located in in Taranto, Italy (ILVA) and in Germany (EEW).

Fabrication was in accordance with DNV OS F-101 for a material grade of DNV 450 IFD. Line pipe wall thicknesses were

- 16,2 mm
- 18,6 mm
- 37,4 mm (buckle arrestors and onshore linepipe)

Nominal linepipe lengths were 12,2 m

Figure 5.01 Buckle Arrestor Fabrication

b. Corrosion Coating

Corrosion Coating of the Balearic Project linepipe was performed by Socotherm in their coating plant located in Albacete, Spain. The coating consisted of a 3-Layer PE/PP with a RoughCoat finish to facilitate optimum adhesion to the concrete weight coating

Figure 5.02 Corrosion Coating

c. Concrete weight Coating

Concrete weight coating of the Balearic Project linepipe was by Bredero Shaw utilizing their mobile coating plant located in the port of Alicante, Spain Coating thicknesses varied from 40 mm to 120 mm, with concrete densities varying from 2.240 to 3.040 kg/m3. To ensure the adequacy of the coating for the foreseen installation and operational conditions the coating was subjected to shear and impact testing. The scope of work also included the installation of zinc half shell anode bracelets

Figure 5.03 Concrete Coating Shear Testing

6 Pipeline Construction

A Contract for the construction of the Balearic Submarine pipeline was awarded to a Joint Venture formed by the companies Saipem and FCC in July, 2007. The scope of work comprised following main activities:

- Pre-lay and Post-lay Survey Activities, including removal of obstructions and relocation of anti-trawling blocks, provision of pipelay and trenching vessel survey support
- Construction and reinstatement of the landfalls in Denia and Mallorca utilizing the open cut method and a pre-dredged channel
- Construction and reinstatement of the landfall in Ibiza utilizing the tunneling method
- Installation of pre-lay cable crossing supports
- Pipeline shore pulls at the Denia, Ibiza and Mallorca landfall points
- Installation of the WoI and EoI pipelines between the designated landfall points in Denia, Ibiza and Mallorca
- Performance of the offshore AWTI (Above Water Tie-ins)
- Trenching and backfilling of the nearshore pipelines
- Protection of cable crossings with rock berms and remedial rockdumping
- Flooding, cleaning, gauging, hydrostatically testing, de-watering and drying of the installed offshore pipelines between the landfalls, including disposal of the linefill water.

A programme indicating the sequence and periods in which the various aspects of the work were carried out is shown in Figure 6.01

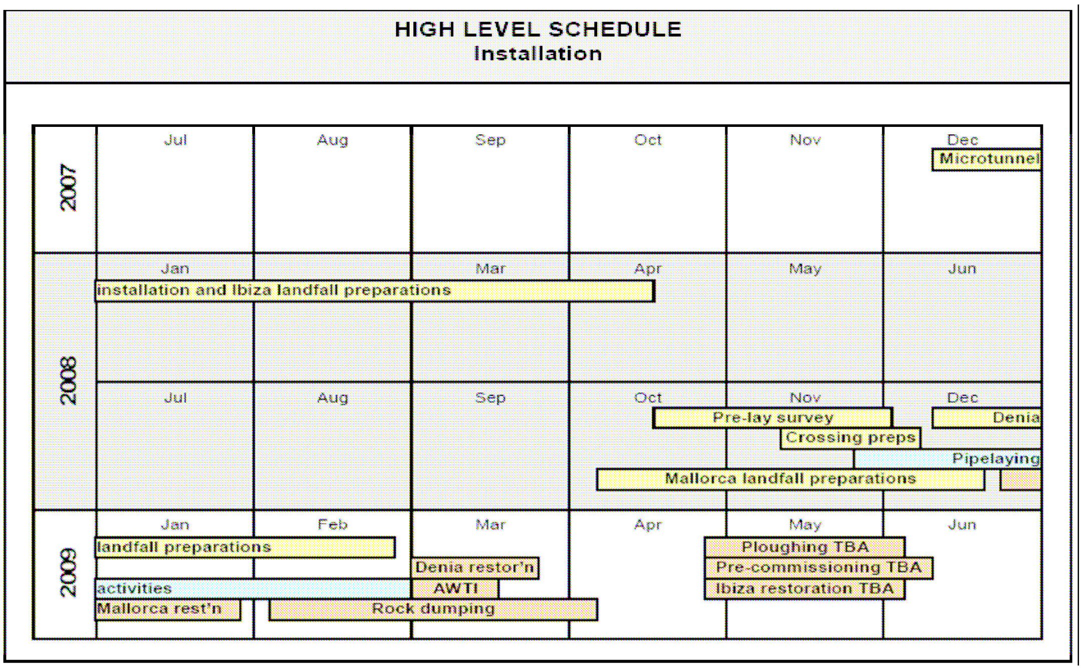

Figure 6.01 Construction Schedule

The main contractors participating in the realization of the work are indicated in Figure 6.02

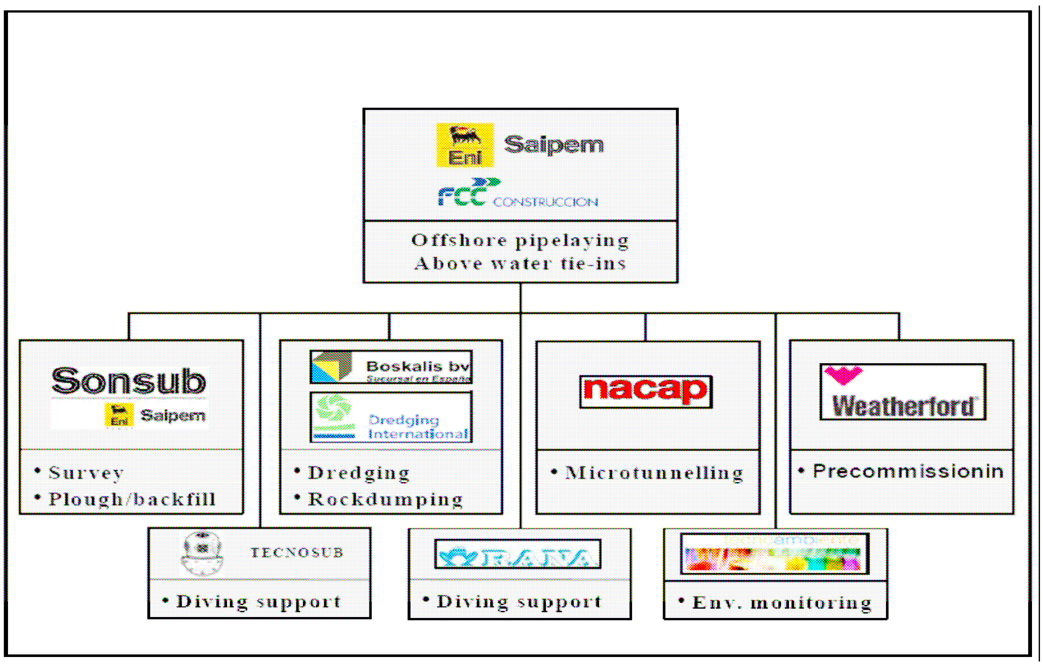

Figure 6.02 Principal Construction Contractors

7 Pre-Installation Activities

a. Pre-Installation Surveys

The scope of the pre-lay route corridor survey can be summarized as follows:

- Definition of detailed bathymetry along pipelay corridor in a region extending ±30m from the route centre line,
- Identification of obstacles in the lay corridor, in a region extending ±30m from the route centre line,
- Identification of hazard and rock/hard-soil in the ploughed sections,
- Identification of potential archaeological findings,
- Inspection of the tunnel exit bellmouths at Ibiza.

The survey was performed on the full extent of the pipeline corridor, with the exception of the shore approaches (due to water depth limitations) by Subcontractor Sonsub using its vessel Vos Sympathy. The survey was performed using an ROV equipped with Multibeam echo sounder (MBES), Side Scan Sonar (SSS), Obstacle avoidance sonar (OAS) and Colour camera.

The pre-lay route corridor survey operations commenced on the 14.10.2008 and were completed on the 01.12.2008.

b. Crossing Preparation

The submarine pipeline routes intersects several existing third-party cables, but only five in service, for which support protection was needed. Crossing details are as following:

Crossing No.	Cable name	Cable type	KP at crossing	WD at crossing (m)	Status
WoI-03	Penbal 4	Fiber optic	101.153	299	Buried / In-service
EoI-06	Penbal 5	Fiber optic	97.420	122	Buried / In-service
EoI-08	Islalink	Fiber optic	101.824	119	Buried / In-service
EoI-14	Islalink	Fiber optic	133.349	49	Buried / In-service
EoI-17	Penbal 4 Seg. B	Co-axial	135.105	46	Buried / In-service

The supports, made of concrete mattresses, were placed linearly on one side of the cable in order for the pipeline to span above the cable at the crossing point.

The mattresses were made of concrete blocks linked by 20mm dia. propylene cast rope. Each mattress had dimensions of 6.0m x 3.0m x 0.3m, with a submerged weight of 4.3t.

The actual cable position was surveyed for a minimum of 100m each side of the proposed crossing point. A sufficient number of mattresses were deployed to ensure that a support was available along the full width of the lay corridor of ±10m at the given angle between the crossing and the pipeline route

A post-deployment survey was made to record the mattresses as-installed position.

8 Landfall Construction

a. General

Due to the steep rocky profile existing at the Ibiza landfall site and to minimize the environmental impact, landfall construction at Ibiza was by the drilling of two tunnels, each of approximately 130m in length. The tunnels commenced onshore and extended seaward, exiting on the seabed at a water depth of approximately 20m

The construction of the landfalls at Denia and Mallorca was accomplished utilizing conventional open-cut dredging techniques. Due to the sandy beach conditions in Denia, a sheet piled cofferdam was installed at this landfall to maintain the required trench configuration. This was not required at the Mallorcan landfall as this consisted of a rocky coastline.

Details of the landfall construction at each of the landfall locations are given in the following sections

b. Ibiza Landfall

The construction of the the two tunnels and the complementary preparatory works carried out at the Ibiza landfall site can be summarized as follows:

1. Construction of 48” Microtunnel

- Excavation and cementing of the two tunnel initiation pits
- Construction of the front cement wall, from where the tunnel boring would commence
- Construction of the back concrete wall (thrust wall), which would provide reaction for the tunnelling equipment to advance.
- Installation of guide rails on the trench floor to guide the tunnelling machine
- Tunnel boring and internal sleeve protection installation
- Construction of a bellmouth protection
- Installation of the bell mouth protection and monitoring cameras at the tunnel offshore exit point

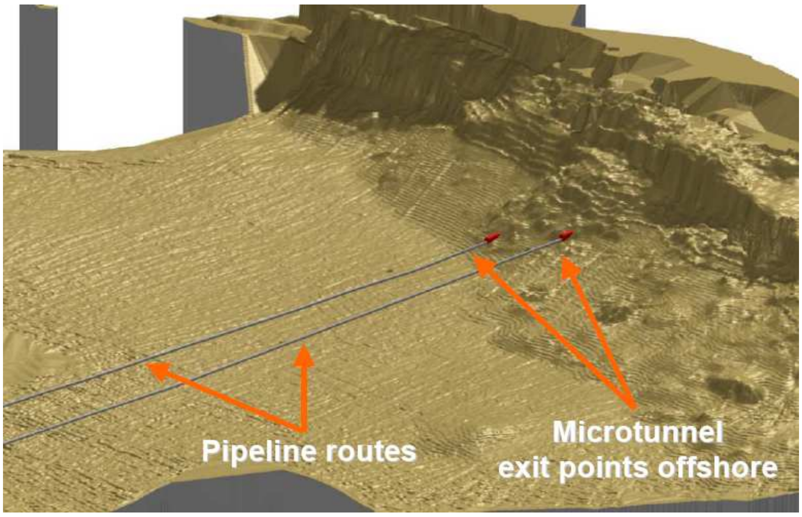

Figure 8.01 Ibiza Landfall Microtunnels

2. Installation of the onshore 300-t linear winch spread

- preparations of winch and reel foundations
- installation of the linear winch and winch reel on their foundations
- installation of required deflection rollers
- pre-laying of the winch pull wire for later retrieval

Overall site activities related to tunnelling activities in Ibiza were performed in the period between 11.12.2007 and 16.04.2008.

Tunnel Construction

The tunnel was created using a tunnel boring machine (TBM) and 48” steel sleeve pipes. The tunnelling machine was installed onto the pre-installed rails in the pit and it’s alignment was confirmed. All electric/hydraulic control lines and slurry hoses were connected. The machine was hydraulically driven and controlled from a control cabin positioned at the surface. A jacking system acting against the thrust wall gradually advanced the tunnelling machine while the 48” steel sleeve pipes were continuously fed into the tunnel cavity as the tunnelling progressed The sleeve pipes remained as a tunnel lining upon completion of the tunnel. Tunnel progress and alignment were continuously controlled by a laser guidance system.

Figure 8.02 Ibiza Landfall Tunneling Machine

Figure 8.03 Ibiza Landfall Tunneling Operations

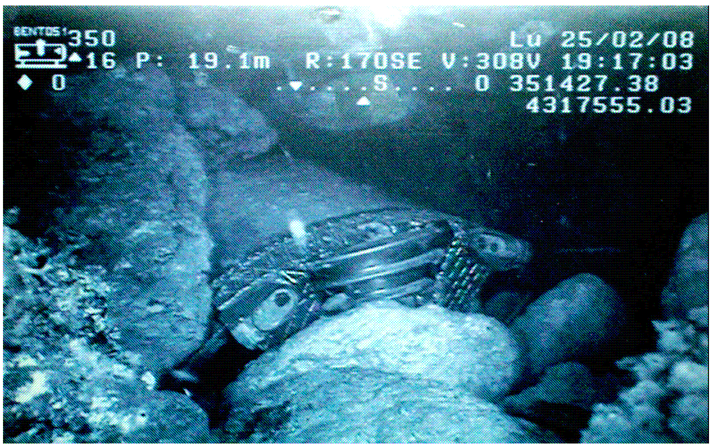

Figure 8.04 Ibiza Landfall Tunneling Exit Point

A bellmouth protection structure was required to prevent the onshore winch pull wire from chafing against the tunnel edge during pipe pulling. The bellmouth protection structure was fabricated by Saipem and installed by subcontractor Tecnosub. Divers also installed a set of monitoring cameras at the tunnel offshore exit point.

A messenger wire was pre-installed into the tunnel to facilitate the subsequent pre-lay of the onshore pull winch wire.

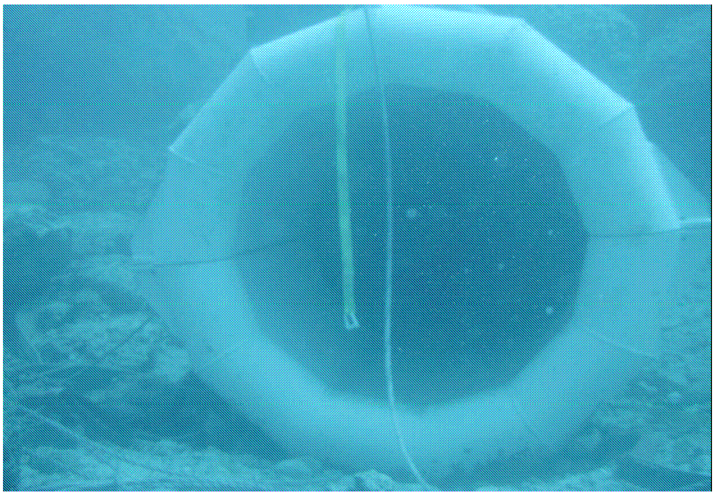

Figure 8.05 Ibiza Landfall Bellmouth

Linear Winch Spread

The winch foundation was prepared by excavating a suitable pit, preparing a micropile anchorage and casting a concrete block to the top of the piles, as a base for the winch.

In advance of the WOI pipe pull operations at the Ibiza shore approach, the onshore pulling winch spread was installed. The spread included a 300 t linear winch on its micropile foundation, a reel winder, and a vertical deflection roller.

The winch pull wire was connected to the messenger line pre-installed into the tunnel, and then pre-laid to the designated pick-up location for later retrieval by Saipem's SSLV Castoro VI at commencement of the shore pull operations.

Figure 8.06 Ibiza Landfall Linear Winch

c. Mallorca Landfall

The pre lay dredging of the trench and the complementary preparatory works carried out at the Mallorca landfall site can be summarized as follows:

- Dredging of the nearshore approach channel,
- Installation of a 500-t pulling winch
- Pre-lay of the onshore winch pulling wire

Site operations for shore pull preparatory work at Mallorca commenced on the 06.10.2008 and were completed on the 18.12.2008.

Pre-dredging survey

An initial survey was carried out by Dredging Subcontractor prior to commence the dredging activities. The scope of the pre-dredging survey was to establish the original seabed level, the proposed temporary dredged material storage areas and the the proposed beach area.

The offshore survey was carried out from a tug equipped with positioning system and multibeam echo sounder. Onshore survey was carried out using standard topographic survey techniques.

Dredging of the nearshore approach channel

The dredged channel extended from the beach towards sea for a distance of approximately 1 km. The dredging activities can be divided into four main parts:

- the excavation of a causeway onshore using land-based hydraulic excavators.
- the excavation of a flotation channel nearshore using backhoe dredger Nordic Giant,
- the excavation of a trenched channel using a spread comprising the backhoe dredger Nordic Giant and two split barges
- the transition zone (ca. 100m long, min. 20m wide) using a spread comprising the backhoe dredger Nordic Giant and two (2) split barges.

Figure 8.07 Mallorca Landfall Onshore Excavation

Figure 8.08 Mallorca Landfall Nearshore Dredging

The channel was dredged to a minimum depth below sea bottom level of 2.2m (except transition zone). The excavated material was disposed into an authorized subsea spoil dumping area, for subsequent use during post-pipe pull backfilling operation. Silt screens were installed to reduce turbidity during the excavation of the flotation channel, trenched channel and transition zone.

As-dredged survey

Upon completion of the dredging activities and prior to commence the pulling wire lay, an as-dredged survey was conducted to ensure that the trench is in accordance with the specifications and the design and the construction drawings.

The offshore survey was carried out from a tug equipped with positioning system and multibeam echo sounder.

Pre-lay of the onshore winch pulling wire for later pick-up by the pipelay vessel

The pulling wire pre-lay was carried out by the vessel Nordic Giant with assistance from the Multicat vessel Multra Salvor. The pulling wire, made of two 1350m long segments, was pulled through the deflection rollers, and then laid along the dredged channel up to the pipelay barge pick-up point.

Onshore winch installation

The pipeline pull at shore approach was performed using a 500 t onshore linear winch. The winch was installed on a light concrete foundation and fixed at the back to a suitable anchoring system. A system comprising a horizontal and a vertical deflection rollers was prepared and anchored to deflect the pulling wire as appropriate. A reel winder was installed at the back of the winch to recoil the pulling wire.

d. Denia Landfall

The pre lay dredging of the trench and the complementary preparatory works carried out at the Denia landfall site can be summarized as follows:

- Dredging of the nearshore approach channel, including installation of a sheet pile cofferdam structure
- Installation of a 500-t pulling winch
- Pre-lay of the onshore winch pulling wire (performed by Subcontractor Boskalis).

Site operations for shore pull preparatory work at Denia commenced on the 13.12.2008 and were completed on the 25.02.2009.

Pre-dredging survey

An initial survey was carried out by Dredging Subcontractor prior to commence the dredging activities to establish the original seabed level, the proposed temporary dredged material storage areas and the proposed beach area. The offshore survey was carried out from a tug equipped with positioning system and multibeam echo sounder. Onshore survey was carried out using standard topographic survey techniques.

Dredging of the nearshore approach channel

The dredged channel extended from the beach out to a distance of approximately 1,5 Km. The dredging activities can be divided into five main parts:

- Installation of two parallel sheet pile walls (cofferdam structure), part onshore and part nearshore, using land-based equipment and vibro-hammer for pile driving.
- Excavation of the cofferdam channel, by means of land-based equipment,
- Excavation of a flotation channel nearshore using a spread comprising the backhoe dredger Nordic Giant and two split barges;
- Excavation of a trenched channel using a spread comprising the backhoe dredger Nordic Giant and two split barges,
- Excavation of transition zone using a spread comprising the backhoe dredger Nordic Giant and two split barges.

Figure 8.10 Denia Landfall Onshore Excavation

The channel was dredged to a minimum depth below sea bottom level of 3m. The material excavated from the cofferdam channel was sidecast for re-use during post-pipe pull backfilling; the material excavated from the dredged channel was temporarily stored in an authorized subsea spoil dumping area, for subsequent use during post-pipe pull backfilling. Silt screens were installed to reduce turbidity, in conjunction with the excavation of the flotation channel, trenched channel and transition zone.

As-dredged survey

Upon completion of the dredging activities and prior to commence the pulling wire lay, an as-dredged survey was conducted to ensure that the trench is in accordance with the specifications and the design and the construction drawings.

The offshore survey was carried out from a tug equipped with positioning system and multibeam echo sounder.

Onshore winch installation

The pipeline pull at shore approach was performed using a 500 t onshore linear winch. The winch was installed on a light concrete foundation and fixed at the back to a suitable anchoring system. A single vertical deflection roller was prepared and anchored to deflect the pulling wire as appropriate. A reel winder was installed at the back of the winch to recoil the pulling wire.

Pre-lay of the onshore winch pulling wire for later pick-up by the pipelay vessel

The pulling wire pre-lay was carried out by the vessel Nordic Giant with assistance from a tug. The pulling wire, made of two 1350m long segments, was pulled through the deflection roller, and then laid along the dredged channel up to the pipelay barge pick-up point.

9 Pipeline Shore Pulls and Pipelay

a. General

Pipeline shore pulls at the three landfall locations was generally accomplished by the use of an onshore linear winch which pulled the pipeline onto the beach from the Castoro VI which was anchored offshore at the pre-defined shore pull position. The winch pull wire, once recovered onboard Castoro VI, was connected to the pulling head. The Castoro VI then paid out pipe which was simultaneously winched onshore. The pull length varied at the three landfall locations due to the nearshore seabed profile and resulting water depths. The main difference between the landfalls was that at Mallorca and Denia, the pipe was pulled into the pre-dredged trenches, while in Ibiza it was pulled into the tunnels. Two shore pulls were carried out at the Ibiza landfall, one for the incoming WOI pipeline and one for the outgoing EOI pipeline.

The sequence of pipelay installation activities was:

- The Castoro VI commenced pipelay of the submarine pipeline at the Ibiza landfall initiating with the shore pull through the WOI tunnel. Following the shore pull it continued pipelay of the WOI pipeline until KP 105,3 where it abandoned the line on the seabed
- The Castoro VI then returned to the Ibiza landfall to perform the shore pull through the EOI tunnel. It then continued to lay the EOI pipeline until arriving KP 42,5 where it abandoned the line on the seabed.

- The Castoro VI then transferred to Mallorca to perform the shorepull at this landfall. It continued to lay the EOI pipeline until arriving at a water depth of 20m where it abandoned the line on the seabed.

Figure 9.01 Mallorca Shorepull Operations

- The Castoro VI then returned to the Ibiza landfall, recovered the EOI pipeline from the seabed at KP 42,5, then continued laying until arriving at the Mallorca where it abandoned the line on the seabed in approximately 20m waterdepth
- The Castoro VI then returned to the Ibiza landfall, recovered the WOI pipeline from the seabed At KP 105, then continued laying until arriving at the Denia where it abandoned the line on the seabed in approximately 20m waterdepth
- The Castoro VI then performed the shorepull at the Denia landfall, then continued to lay the WOI pipeline until arriving at a water depth of 20m where it abandoned the line on the seabed.
- Tie-ins between the four abandoned sections in Denia and Mallorca were later carried out by Saipem's vessel, the Crawler

The vessel spread which comprised the various support vessels assisting the Castoro VI during laying operations consisted of:

- 3 AHTs: Blizzard, Boulder, Sea Lynx
- 3 Pipe Carriers: Normand Flipper, Normand Aurora, Normand Carrier
- 1 Supply Vessel Ocean Mainport
- 1 Survey Vessel :Grampian Surveyor
- Additional Tugs for "DP Napoletano", Far Sovereign, N. Chaser, Sea Bear

Figure 9.02 SSLV Castoro VI

Principal construction processes aboard the Castoro VI were:

- Welding Process: Main Line Passo, Double Joint :SAW
- NDT System: Saipem AUT System
- Heat Shrink Sleeves: MIS 65 - Canusa
- Field Joint In Fill Material: Solid PU with Aggregate

Figure 9.03 SSLV Castoro VI

During shore pull and pipelaying operations, the vessel internal and external ramp angles, the associated roller support heights, and the vessel lay tension were set to the values specified within the engineering analysis reports. A total of six different ramp and roller configurations were defined as being required. For the deep water configuration, a ramp extension structure complete with two additional roller supports was installed on the external ramp tip.

During the laying through the deep water section, Castoro Sei was also towed by a front tug (Far Sovereign) and two lateral live anchors replaced two standard anchors.

Details of the shore pulls and pipelay activities for the WOI and EOI pipelines are given in the following sections.

b. WOI Pipeline

The WOI pipelay operations consisted in the lay of the pipeline from landfall point in Denia to the WOI tunnel entry point (onshore) in Ibiza, using Saipem SSLV Castoro VI with her vessel spread.

For the purpose of the pipelaying, the line was split in two (2) sections, defined as Section 1 and Section 2, as detailed below:

	Start	**End**
WOI - Section 1 **Ibiza to AWTI**	**WOI microtunnel entry point** **KP 123.350**	**WOI AWTI target point** **KP 5.497**
WOI - Section 2 **Denia to AWTI**	**Denia landfall point** **KP 0.990**	**WOI AWTI target point** **KP 5.516**

For each section, the following main activities were carried out:

- Pipe pull at shore approach
- Normal pipelay
- Laydown within the pre-determined AWTI (Above Water Tie In) target box.

The WOI shore pull at Ibiza was performed using a 300-t onshore winch, while the WOI shore pull at Denia was performed using a 500-t onshore winch.

The total length of pipeline laid (including shore pulls) was 122.479km. The maximum water depth reached was 995m at KP 70.730.

The WOI pipelay activities commenced on the 25.11.2008 and were completed on the 28.02.2009.

c. EOI Pipeline

The EOI pipelay operations consisted in the lay of the pipeline from the EOI tunnel entry point (onshore) in Ibiza to landfall point in Mallorca, using Saipem SSLV Castoro Sei with her vessel spread.

For the purpose of the pipelaying, the line was split in two sections, defined as Section 1 and Section 2, as detailed below:

	Start	End
EOI - Section 1 **Ibiza to AWTI**	**EOI microtunnel entry point** **KP 0.890**	**EOI AWTI target point** **KP 144.631**
EOI - Section 2 **Mallorca to AWTI**	**Mallorca landfall point** **KP 146.557**	**EoI AWTI target point** **KP 144.456**

For each section, the following main activities were carried out:

- Pipe pull at shore approach
- Normal pipelay
- Laydown within the pre-determined AWTI target box.

The EOI shore pull at Ibiza was performed using a 300-t onshore winch, while the EOI shore pull at Mallorca was performed using a 500-t onshore winch.

The total length of pipeline laid (including shore pulls) is 145.842 m. The maximum water depth reached was 720 m at KP 70.306.

The EOI pipelay activities commenced on the 05.12.2008 and were completed on the 17.01.2009.

10 Above Water Tie Ins (AWTI)

The AWTI operations consisted in the tie-in of the four pipeline sections (two in Denia and two in Mallorca), previously installed and abandoned on the seabed by the SSLV Castoro VI. These tie-ins were performed in approximately 20m water depth which occurred In Denia at approximately 4.5 km from the coast and In Mallorca at approximately 2 km from the coast.

The AWTI was performed by Saipem's vessel, the DLB Crawler using it's six davits to lift the two pipeline sections to the surface. In addition, buoyancy tanks were installed on the pipeline to reduce the pipeline weight.

Once that the DLB Crawler was moored on site, divers were used to perform the connection the buoyancy tanks to the pre-installed clamps.

Completed the buoyancy tanks installation, divers connected the six lifting davit lines (deployed from DLB Crawler) to the relevant lifting clamps.

The operation started by lifting the two sections from the seabed to the surface in a controlled manner

A pre-installed working platform was raised from the barge side to the horizontal position under the end of the pipeline sections. A cutting position was identified on each pipeline section; the head plus any excess pipe were cut off and removed. The pipe ends were beveled and an external clamp installed to align the two sections in order to start welding operations. Once completed, the weld was checked by manual UT.

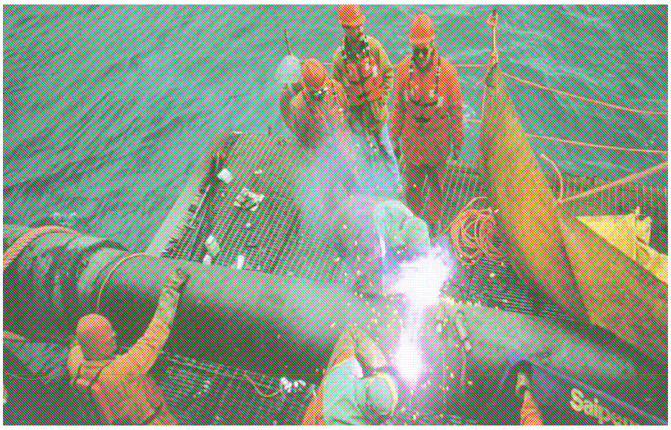

Figure 10.01 Above Water Tie-In

The field joint coating activities consisted of applying heat shrink sleeve to the welded area and subsequently injecting infill material into the annulus to restore the concrete weight coating continuity. A transponder was also installed on the welded section to track the pipeline position during lowering.

Upon completion of the above activities, the working platform was removed, and the pipeline was lowered to the sebed..

The lowering was performed in steps, alternating barge sideways movements to davit line payouts, in order to achieve a minimum bending radius of 300m.

Upon completion of the lowering operations, the divers disconnected the davit lines from the clamps, removed the buoyancy tanks and disconnected all clamped fastenings.. The divers also disconnected the lifting clamps and of buoyancy tank clamps, which were recovered onboard the DLB Crawler.

11 As Laid Survey

The scope of the as-laid survey was as follows:

- To provide relevant documentation that demonstrated that the pipeline had been laid on the seabed in accordance with Client specifications
- To verify by inspection that no debris or other anomalies were present that might interfere with ploughing or backfilling activities
- To verify by video inspection of the top and both sides of the as-laid pipeline that the pipeline, coating, anodes, etc. were in a good and undamaged condition
- To identify and define any freespans; at freespans exceeding the allowable installation length temporary restraints in the forms of sand bags / salt sacks were placed on both sides of the line
- To establish the as-laid position of the pipeline, including all engineering features such as Field Joints, Anodes, etc.
- To verify the as-laid position of the pipeline over the mattress crossings locations
- To inspect the microtunnel bellmouths at Ibiza.

The as-laid survey was performed on the sections laid by the SSLV Castoro Sei along all of the WOI and EOI routes, with the exceptions of the areas close to the shore approaches, by Subcontractor Sonsub using its survey vessel Grampian Surveyor.

The survey was performed using an ROV equipped with bathymeter and altimeter (B+A), Obstacle Avoidance Sonar (OAS), Dual Head MBES profilers, and Colour Camera.

The as-laid survey operations commenced on 14.12.2008 and were completed on the 01.03.2009.

12 Trenching and Backfilling

a. General

Trenching and backfilling operations in the nearshore areas of Mallorca and Denia were carried out by the PSV Far Sovereign utilizing the Advanced Pipeline Plough PL2 and the Backfill Plough BPL2.

All the ploughing and backfilling was carried out with the pipeline in the empty condition

The target depth for trenching the pipeline was 1.5m. The target pipeline burial depth was 0.5m measured from the top of pipe

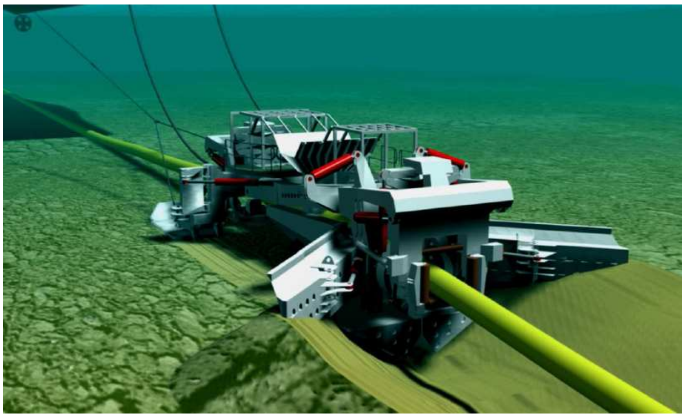

Figure 12.01 Post Trenching Plough

b. Mallorca

The EOI trenching operation consisted of the ploughing and backfilling of the nearshore pipeline section at Mallorca. The EOI ploughing activities commenced on 11.03.2008 and were completed on 12.03.2009. The EOI backfilling activities commenced and were completed on 26.03.09.

A summary of the EOI pipeline section that was trenched and backfilled is as follows:

Pipeline	Trenched and Backfilled Section		Trenched and Backfilled Section Length	Water Depth [LAT]	
	From KP	To KP		Min	Max
EOI	KP 141.205	KP 145.667	4.462 m	12,3 m	38,8 m

The plough was configured to trench the EOI pipeline section in two passes.

Throughout the period of the 1st and 2nd passes of the ploughing operations environmental monitoring was carried out to establish turbidity levels in the water column, approximately 400m astern of the PSV and 200m astern of the plough.

Plough roller loads and alarm settings were set in accordance with the project “Ploughing Stress Analysis” documents. The maximum tow force experienced on the 1st pass was 237 Te.

An intermediate survey was completed by the PSV to confirm the status of the trench and check for any debris that may be hazardous to the trenching operation.

The 2nd pass of the EOI ploughing operations encountered the presence of fractured calcarenite at approximately 1.5m below the seabed. The tow forces required to pull the plough were high and the plough stopped on three occasions when it hit harder rock.

The results of the post survey found that sections of rocky outcrops occurred, where there was a lack of backfill material, leaving the pipeline exposed. The backfilling operations where carried out throughout the entire section, however remedial works were deemed necessary in some of the areas where pipeline was found exposed on completion of as backfilled survey.

c. Denia

The WOI trenching operation consisted of the ploughing and backfilling of the nearshore pipeline section at Denia. The WOI ploughing activities commenced on 16.03.2008 and were completed on 18.03.2009. The WOI backfilling activities commenced on 21.03.09 and were completed on 23.03.09.

A summary of the WOI pipeline section that was trenched and backfilled is as follows:

Pipeline	Trenched and Backfilled Section		Trenched and Backfilled Section Length	Water Depth [LAT]	
	From KP	To KP		Min	Max
WOI	**KP 2.600**	**KP 16.789**	**14,189 m**	**13.2 m**	**73.6 m**

The plough was configured to trench the WOI pipeline section in a single pass with the assistance of an anchor handling tug to provide additional towing force.

Plough roller loads and alarm settings were set in accordance with the project “Ploughing Stress Analysis” documents. The maximum tow force experienced during the trenching operations was 295 Te.

An Anchor Handling Tug (AHT) “Boulder”, was connected to the bow of the Far Sovereign to apply additional in-line towing force.

The results of the post survey found a section of the ploughed trench had collapsed; the pipeline was not visible to the ROV cameras, and was covered by natural backfill of the collapsed spoil. It was therefore not possible to carry out backfilling activities with BPL2 in this section but it was concluded the the pipeline was adequately protected.

Backfilling operations commenced but encountered a clay build-up in front of the BPL2 machine which prevented backfilling operation to be completed. Remedial work was therefore performed in the form of parcial sand and rock-backfilling.

13 Rock Dumping

a. General

The rock dumping operations were performed by Subcontractor Dredging International using rock dumping vessels Rolling Stone (RS) and Sea Horse (SH), and covered services for rock placement on the sea bottom for the following scope:

- To mitigate in-service lateral pipeline deflection,
- To stabilize/protect the pipeline at microtunnel exit point,
- To protect the WoI-03 cable crossing,
- To rectify freespans exceeding installation or operational allowable length - Sea Horse up to water depths of 400m and Rolling Stone in water depths greater than 400m,
- To supplement backfill covers on ploughed sections.

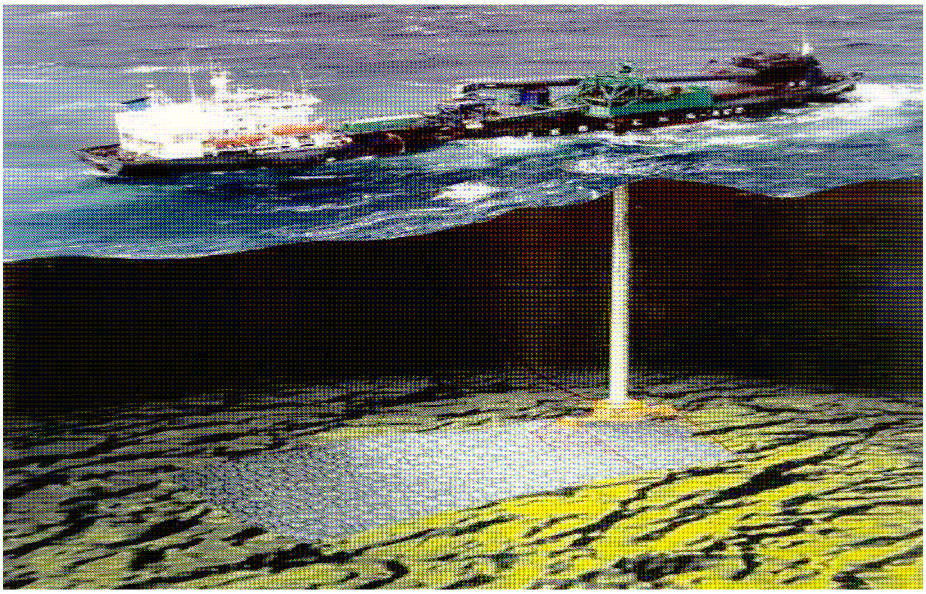

Figure 13.01 Rock Dumping

A survey by the rock dumping vessel was carried out prior to each rock dumping activity (pre-survey), as well after its completion (as-built survey), using an ROV equipped with Multibeam echosounder (MBES).

b. WOI Pipeline

For the execution of the rock placement works, a double-layer consisting of 1”-4” / 1-5” (filter layer) and 3”-8” / 3”-12” (armour layer) well graded rock was used. A total of 17 370 t of rock was placed along WOI pipeline. Double layer was used in water depth less than 77m, and a single layer used for water depth greater than 77m.

c. EOI Pipeline

For the execution of the rock placement works, a double-layer consisting of 1”-4” / 1-5” (filter layer) and 3”-8” / 3”-12” (armour layer) well graded rock was used for intervention at water depth less than 77m. For water depth greater than 77m a single (filter only) layer was used. A total 22.325 t of rock was placed along the EoI pipeline.

14 Pre Commissioning

Following completion of pipelaying and AWTI activities, the pipelines were subject to hydrotesting and pre-commissioning which included the following activities:

- Post Lay pre-Flooding Activities
- Cleaning and Gauging Activities
- Hydrostatic testing Activities
- Dewatering Activities
- Drying Activities

a. Post Lay pre-Flooding Activities

In order to better control the cleaning and gauging pig train and avoid excessive pig speed, the pipelines were pre-flooded with filtered seawater from the Ibiza landfall location where the spread for pre-flooding was located. No scrapers or other mechanical devices were inserted into the line during the pre-flooding operations.

Prior to commencement of pre-flooding operations and in order to minimise the water/air mixing, the majority of ambient air within the pipeline was expelled using vacuum pumps. Vacuum pumps were installed both on Ibiza and Denia landfall locations.

On attaining approximately 100 mBar pressure, the vacuum pump at Ibiza location was shut down and pre-flooding water injection commenced. The vacuum pump at Denia/Mallorca location remained operational until the pipeline was approximately 80% filled with filtered seawater.

b. Cleaning and Gauging Activities

On completion of Pre-Flooding operations, the Cleaning and Gauging pig train was introduced into the pipeline from Ibiza. The water within the pipeline was used as a hydraulic pig speed control column with the subsequent pig run being controlled around 0.6 m/sec using a discharge valve at the Denia/Mallorca end of the pipeline. The pig train consist of five bi-directional pigs separated by filtered seawater.

The Cleaning and Gauging pig train was propelled using the pumping spread installed on Ibiza and previously used for pre-flooding operations.

All pre-flooding water within the pipeline was discharged through break tanks in order to filter and retain potential debris. From there it was pumped into the sea. Approximately 100 m (~18 m3) of water in front of each pig was been collected and stored in the break tanks for filtration and settlement before evaluation and correct disposal. All retained soil in the tank was removed and handed over to authorized disposal company.

Upon receiving of complete pig train, the receiver was removed from the pipeline and pigs were recovered. All pigs and gauging plated were inspected to confirm that no significant damage had occurred.

c. Hydrostatic Testing Activities

Following successful completion of Cleaning and Gauging operations, the Pig launcher on Ibiza and the Pig receiver at Denia/Mallorca were removed and testing blind flanges were installed at each location. The Hydrostatic test was preformed from the Ibiza location.

Pressurizing of the pipeline was carried out during the night with the aim of arraving at the required test pressure of 261.5 barG before the morning hours. This was followed by a thermal stabilization period of approx. 12 hours.

During the following 24 hours hold period, no significant pressure loss was observed and the hydrostatic test of the pipeline was deemed acceptable.

After successful completion of hydrostatic test, the pipeline was depressurised to atmospheric pressure in a controlled manner.

d. Dewatering Activities

Once the pipeline was depressurised to atmospheric pressure, Testing blind flanges were removed and replaced with a pig launcher, preloaded dewatering pigs at Ibiza and the pig receiver at Denia/Mallorca.

The dewatering pig train consist of eight bi-directional batching pigs separated by either potable water or compressed, oil free air.

The dewatering pig train was propelled from Ibiza location using dry, oil free compressed air. Potable water slugs were taken from the nearby desalinization plant at Ibiza and incorporated in the pig train to rinse any residual salt from the pipe wall. Water samples were taken during the receipt of the last potable water slug and measured salt content was recorded.

All water within the pipeline was discharged through break tanks in order to filter and retain potential debris. From there it has been pumped to the sea. Approximately 100 m (~18 m3) of water in front of first 4 pigs was collected and stored in the break tanks for filtration and settlement before evaluation and correct disposal. All retained soil in the tank was removed and handed over to authorized disposal company.

Upon receipt of the complete dewatering pig train, the residual pressure in the pipeline was recorded. Thereafter, the pipeline was left to vent down to atmospheric pressure through preinstalled silencers in order to maintain noise levels within the allowable limits.

When the pressure in the pipeline equalised with atmospheric pressure, the pig receiver was removed, the pigs were recovered and inspected to confirm that no significant damage had occurred to the pigs.

e. Drying Activities

As a final stage of pre-commissioning and following completion of dewatering operations, the pipeline was dried. Drying was carried out from the Ibiza launcher using dry, oil free air until reaching the plateau i.e. dew point reading of -40.0 ℃ at Denia /Mallorca. At that stage, injection of dry, oil free air was stopped and pipeline was isolated for 12 hours Soak Test.

After the 12 hours soak test, purging of the pipeline with dry, oil free air continued until the equivalent of 2 pipeline volumes had passé thru the line and until the plateau within 5 ℃ of the inlet point was achieved. At a dew point reading of -47 ℃ on Denia/Mallorca side, drying of the pipeline was successfully completed and it was isolated with positive pressure of 1barg.

15 Other issues

a. Environmental Control During Construction

A Project Environmental Management Plan and Detailed Management Plans for the main activities were prepared, fulfilling requirements established by the local Environmental Authorities. These plans identified the impacts generated by working activities and proposed preventive, minimising and corrective measures.

In addition Environmental Monitoring Plans were prepared in order to allow acquisition of data relating to environmental conditions before start of works, during work activities and immediately at the end of each work activity.

The main parameters controlled during construction were:

. Sedimentation rates

. Changing of the granulometry size in the sandy sea bottom

. Turbidity levels

. Presence of oil on the sea surface

. Modification in the benthic communities

. Frequencies and noise levels produced in the Cetacean area

. Health status of *Posidonia Oceanica*

The control of these parameters provided information regarding the state of the environment before the start of the works and about the efficacy of the corrective measures implemented.

b. Fishing Interaction

The pipeline passes through a significant proportion of the main fishing grounds for vessels based at the surrounding Mediterranean ports. Three broad categories of commercial fishing occur in the general area of the pipeline, namely;

- Static gear methods – netting, long-lining and potting
- Mid-water (pelagic) methods– surround nets and purse seining
- Demersal trawling – bottom otter trawling

During the installation phase, vessels could be affected by having certain aspects of their traditional fishing areas disrupted and by having to avoid construction vessel exclusion zones until operations had been completed. However, upon completion of pipe-laying operations, displaced static gear or mid-water methods could be re-deployed in original fishing areas, not, therefore, sustaining any material adverse impact from the presence of the operational pipeline. With reference to bottom otter trawling the disruption of existing fishing patterns would continue during pipeline operation.

A Fishing Interaction Study was performed by Brown & May Marine Ltd, in order to provide information regarding the ports involved, vessel activities by port, effort/catch analysis and previous experiences regarding fishing/submarine pipelines interactions.

As a result of Satellite Tracking Data, 10 ports (7 in mainland Spain and 3 in Balearic Islands) were identified, involving 120 bottom otter trawlers and more than 200 vessels operating other fishing methods.

Final agreements with affected ports were based on:

a) During pipeline installation

Compensation payments for temporary displacement, providing information regarding:

- The routes and schedules of installation vessels.
- The locations and schedules or any rock dumping activities.
- The schedules and routes of inshore trenching activities.
- Details and photographs of the installation vessels deployed, including descriptions of safety exclusion zones, anchor spreads and trenching spreads.
- Details of the transit routes and schedules of survey, anchor handling and pipe-supply vessels

b) During Operational Period (trawlers)

Several trials, including different conditions of sea bottom, meteorological, water depths and vessels were performed in order to determine and test a safe way to proceed for crossing the pipeline.

During such trials, the need for using devices which provided detailed information to the vessels regarding the relative situation pipeline/trawl doors, was established and SIMRAD selected as the supplier for such equipment.

16 Other Contractors

a. JP Kenny

The Engineering Company JP Kenny was involved with the Balearic Submarine Pipeline Pipeline from the early conceptual stages, performing preliminary studies for the Government of the Balearic Islands. They continued their involvement in the project for Enagas performing, firstly the Basic Engineering Design, followed by Detailed Engineering and finally providing engineering and supervisory support services during the construction of the submarine pipeline

b. Heymo Ingenieria S.A.

Heymo provided detailed engineering and supervisory support to Enagas for the construction of the onshore facilities (valve stations and compressor station) as well as acting as the "Director Facultativo" (legal engineering authority) for the Balearic Project

c. SCI (Servicios de Control e Inspeccion, S.A.)

SCI acted as the official third party certifying authority for all aspects of welding, NDT and hydrotest activities

d. Bureau Veritas

Bureau form their offices in Madrid and Paris provided third party Verification and Certification services for all pipeline design and construction activities.

e. Inypsa Informes y Proyectos, S.A.

Inypsa provided environmental engineering services to the project, monitoring and controlling all aspects of the work including landfall construction and offshore dredging and pipelay to ensure compliance with all relevant environmental regulations and to ensure minimum project impact to the local environment.

References

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[3] Balearic Submarine Pipeline Project Report, DFI Resumen, J.P. Kenny, June 2009