Recovery of the Fuel from the Prestige Tanker

Paris, October 6th, 2003

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1. Background

Background

- The Prestige tanker split into two and sank off the coast of Galicia on November 19th, 2002, carrying some 79,000 Tm of heavy M100 fuel.
- The bow sank to a depth of 3,840m, and the stern to 3,560m, both sections being some 3,000m apart.
- During the sinking and over the next few weeks and months, an large amount of fuel was spilt and ended up mainly on the Galician coast, but also in the rest of the Spanish northern coast. Smaller amounts ended up in the French coast
- Between the months of December 2002 and February 2003, the french submarine Nautile, working on behalf of the Spanish Administration, managed to reduced the fuel leaking from the tanker from an estimated 130 Tm/day to some 2.2 Tm/day.

Background

- Soon after the sinking of the Prestige, the Spanish Administration put together a Scientific Advisory Committee that completed its work with a report issued on February 13th, 2003.
- This report recommended pumping out the fuel from the cargo as a first option and confining it as a second alternative.
- The amount of fuel estimated at this stage to remain at the wreck was 38,000 Tm

Background

- On February 14th 2003, the Spanish Government entrusted Repsol YPF to study possible solutions and requested the company to recommend a course of action within three months.
- Repsol YPF accepted the task and rapidly formed an internal Project Team that now includes some 40 experts.
- Additionally, an International Technical Committee was put together with representatives of other five other Oil&Gas companies highly experienced in Exploration and Production in Deep Water: BP, Eni, Petrobras, Statoil and Total.
- The International Technical Committee met in March to analyse the problem and make firm recommendations. An action plan was drawn up with the unanimous agreement of all Committee members. This plan was presented to the press on April 4th in Santiago de Compostela, Galicia

Background

- On April 24th, an Agreement was signed between the Spanish Administration and Repsol YPF for the execution of the previously submitted Action Plan. A Coordination and Follow Up Committee was created, with 3 representatives from the Spanish Administration and 2 from Repsol YPF. The Committee meets once a week.
- On May 20th and 21st, the second International Technical Committee meeting took place in Móstoles (Madrid) where the evaluation of a detailed programme of operations was presented.
- Just two months after the Agreement was signed and according to the plan proposed by Repsol YPF and approved by the Administration, on June 26th the MV Polar Prince sailed from Aberdeen equipped with 4 work class ROV's, arriving to the Prestige's site on July 4th, the date that operations commenced.

2. Action Plan

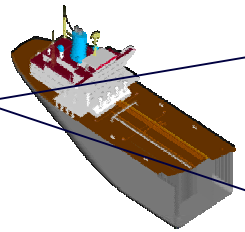
Action Plan as agreed

- **The Action Plan agreed by the International Technical Committee can be summarized as follows:**
  - **Develop Work-Class ROVs to operate at 4000m depth. For Safety Reasons, manned submarines shall not be used**
  - **Enhance the integrity of current sealing devices at the wreck**
  - **Carry out a Data Acquisition Campaign over the Prestige wreck to enable future intervention**
  - **Carry out a number of studies, including fuel property analyses and simulations at seabed conditions and tanker integrity and stability analyses**
  - **Test, if possible during the summer of 2003, a gravity extraction scheme using shuttle bags**
  - **Perform basic engineering studies of confinement solutions as an alternative to be formally proposed if the above scheme does not work,**
  - **Given de depth of the wreck and the enormous viscosity of the fuel at sea bottom conditions, pumping is considered unlikely to succeed, although it should be further studied in case the above does not work**

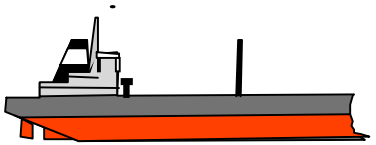
Action Plan

1. Preparation of Marine Operations and Technology development
   - •3D Model of Prestige
   - •Simulation of fuel behaviour
   - •Simulation of the filling up of the bags
   - •Etc.

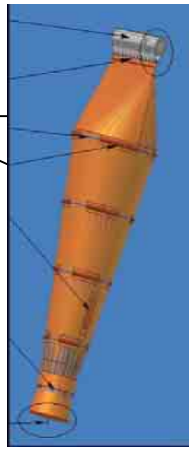
2. Marine Operations Data acquisition



- FUEL DOES NOT FLOW → SHUTTLE BAGS TEST → No flow

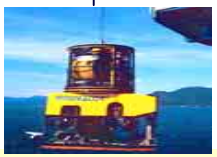


- FUEL FLOWS (LIQUID) → SHUTTLE BAGS TEST → Positive / Positive



- Ship
  - Polar Prince

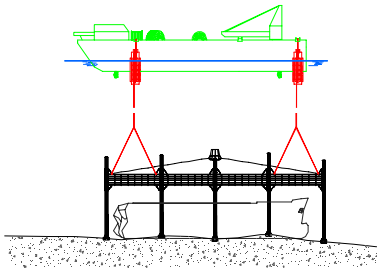
- ROV's
  - SONSUB

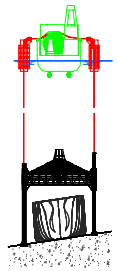


  - THALES

- Negative

3. Confinement Design Basis and Basic Engineering
   - CONFINEMENT





Action Plan: Studies Performed

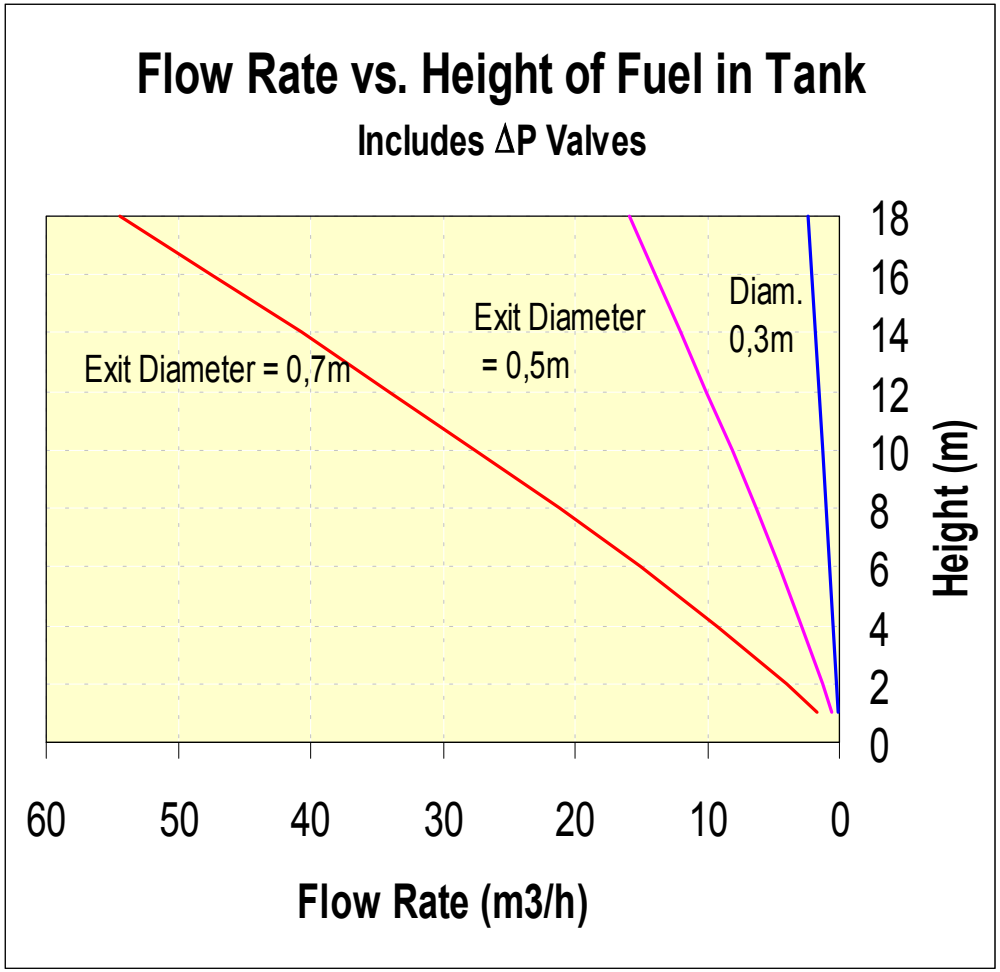
Most studies have been performed in collaboration with Spanish universities and institutions:

- **Meteorological and oceanographic desk studies**
- **Numeric modelling and continuous prediction of winds, waves, currents, etc.**
- **Bathymetry of the area of sinking**
- **Geological description and report of the area**
- **3D Model of the Prestige wreck**
- **Measurement of local currents**
- **Laboratory study and numerical simulations of the fuel behaviour at the wreck's pressure and temperature**
- **Synthesis of a fuel that behaves at surface like the Prestige fuel at the wreck's P&T**
- **Identification of environmental risks**
- **Study of films, photomosaics and other observation data acquired by Ifremer using the Nautile**
- **Oceanographic campaign using the Spanish Oceanographic vessel Hesperides**

3. "Extraction by Gravity"

(Fuel Extraction Studies, Hot Tap and Shuttle Design & Construction)

Action Plan: Fuel behaviour



$$Q = K\ D^3\ h^{1.4}$$

- Due of the high pressure (383 bar at the bow) and to the low temperature (water temperature 2,6 ºC) the fuel viscosity has increased enormously
- Laboratory tests show that under these conditions the fuel has a viscosity of 18 million centipoises at low shear rate (moving very slowly), that reduces to some 3 million of centipoises when it moves faster. This behaviour is called pseudo-plastic
- Experiments and calculations show that, in spite of this enormous viscosity, the fuel maintains a fluid behaviour and is able to flow at low velocities.
- This implies that the orifices made to allow the fuel to flow must have the largest possible diameter

Hot-Tap and Extraction Valve Design

The system is designed to perforate the Prestige deck using a purpose-designed machine that installs and tests a double Extraction Valve <u>before</u> perforating the wreck

Once this valve is tested and anchored, a 70 cm diameter hole is drilled through it and left closed by the double valve

This development is a world first, in terms of water depth, diameter and safety features

Shuttle Bag Design

- Two 250 m^3 fuel volume (some 320 m^2 total volume) shuttle bags have been designed and built to test alternative designs
- One is reusable with disposable liner whilst the other is fully disposable
- Both are double-layered for environmental protection

Archivo MPG

Note: Some aspects of the operation have been modified respect to what is shown in the film

4. Marine Operations

Polar Prince

ROV Technology Development

- Four work class ROV's of two different makes were developed (Sonsub's Innovator and Thales G4) undertaking changes on the umbilical, buoyancy, manipulators, cameras, illumination, etc.

- In early July, the two Innovator ROVs were successfully tested at a depth of 4000 m and on July 6th both worked simultaneously at this depth, establishing a world first

ROV Technology Development (2)

- By mid July, also the two Thales ROVs were succesfully tested to 4000m depth.

- Up until August 24th, the four ROVs had worked a total of 1096 hours of which 252 were completed with two ROVs working simultaneously, resulting in more than 27 hours/day of continuous ROV work.

- The development of the ROVs, their work capacity and the time statistics of their use, clearly demonstrates the significant technological progress that this operation implies.

Leak Sealing

- The first tasks undertaken by the ROVs were the inspection, cleaning and preparation of the leaks for subsequent sealing.

- Subsequently, work was carried out on 11 leaks on the bow and on 4 on the stern, using several sealing methods, i.e. plugs, sand bags, foam, resins and plastic bags. Total time dedicated to this operation was 11 days.

- To date, any remaining leaks can be considered to be minimum to non-existing, with a total flow rate of less than 10 kg/day from the bow as well as from the stern (prior to this intervention, leaks were estimated at some 700 kg/day).

- For all practical purposes, the wreck is now sealed. We consider this to be an important precedent for future

Measurement of Fuel Tank Levels

- Tools manufactured by different companies were tested using a synthetic fuel designed to have the same characteristics at surface conditions as the Prestige fuel at sea bottom conditions. This synthetic fuel was created at Repsol YPF's Technology Centre in Móstoles, Madrid

- Repsol YPF decided to adapt the Thermal Neutron tool used for the identification of oil in hydrocarbon exploration for the determination of the fuel levels in the tanks. Also, a special system for protection and buoyancy control of the tool was designed.

- This tool emits Thermal Neutron which penetrate the hull plate, losing energy when travelling through the fluid and emitting a gamma radiation of varying intensity depending on the nature of the fluid. This method allows the determination of the Carbon/Oxygen ratio, which is high on hydrocarbons and very low on water.

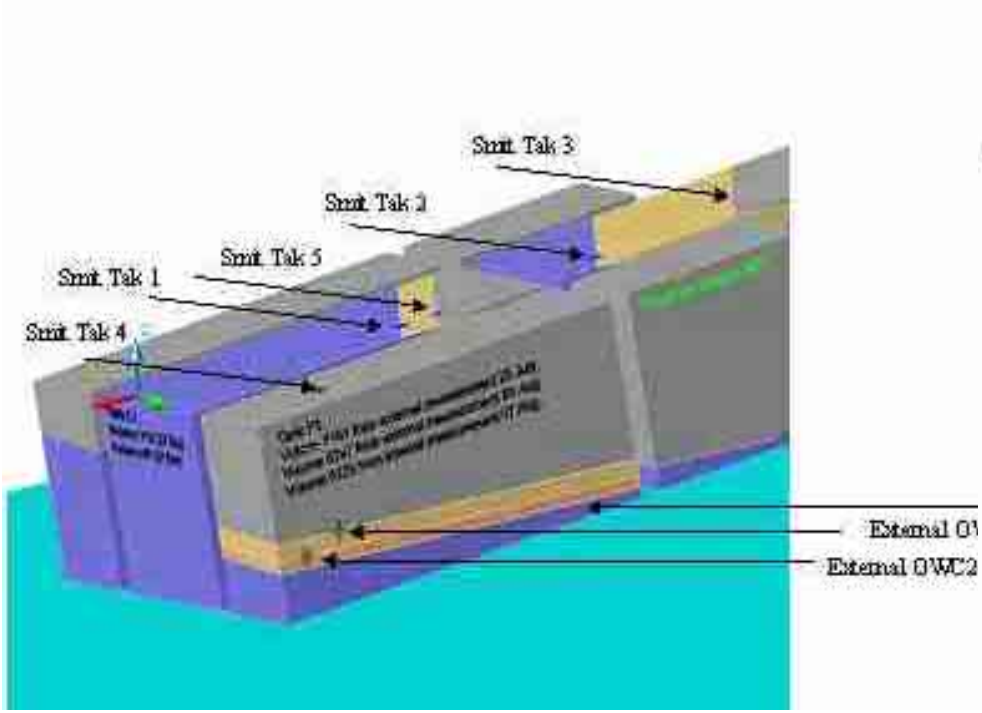
- A blind casing was used to facilitate measuring the fuel level of the central tanks. The casing was introduced by the ROVs through the selected Butterworth openings. Subsequently, the Neutron Tool was lowered through the casing, defining the fuel/water contact, as done in oil wells.

Measurements of Fuel Tank Levels (2)

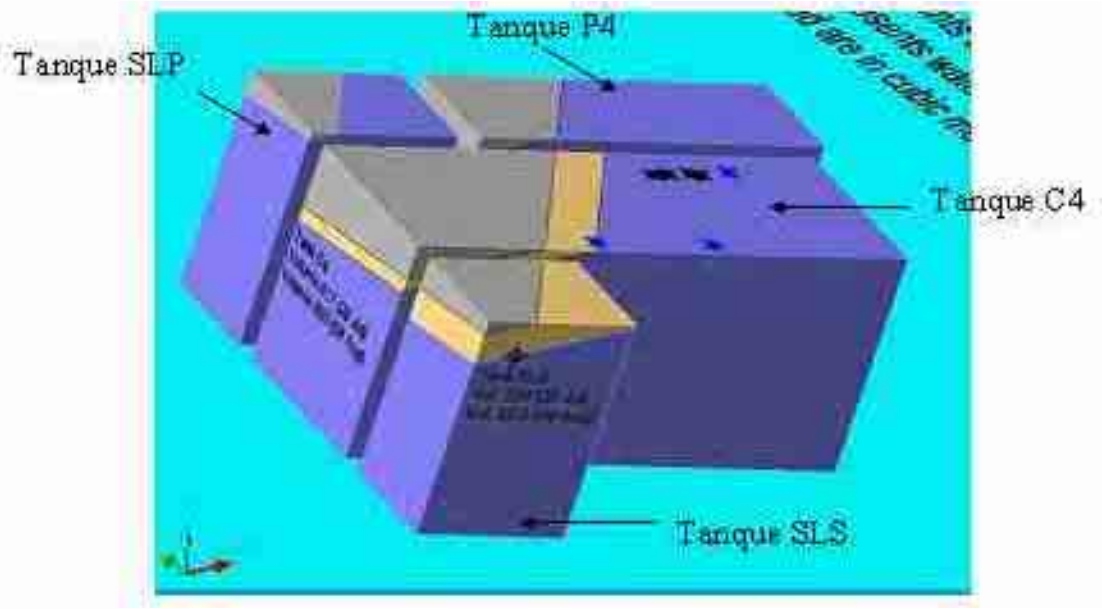
- More than 30 level determinations were done over a period of 9 days.
- Only 700 metric tons were found to remain in the stern.
- It was established that some 13,000 metric tons still remained in the port and starboard lateral tanks in the bow wreck. No fuel was found in the central tanks.
- Although final values will be obtained after calculations made using a tri-dimensional model of the wreck, it is estimated that the previously mentioned figures have an accuracy of +/- 10%.
- This is the first time that fluid levels and volumes have been measured in tanks of sunken ships at great depth. Once again, this represents a technological breakthough for the study of similar wrecks and a significant precedent.

Measurements of Fuel Tank Levels 3-D Model

BOW

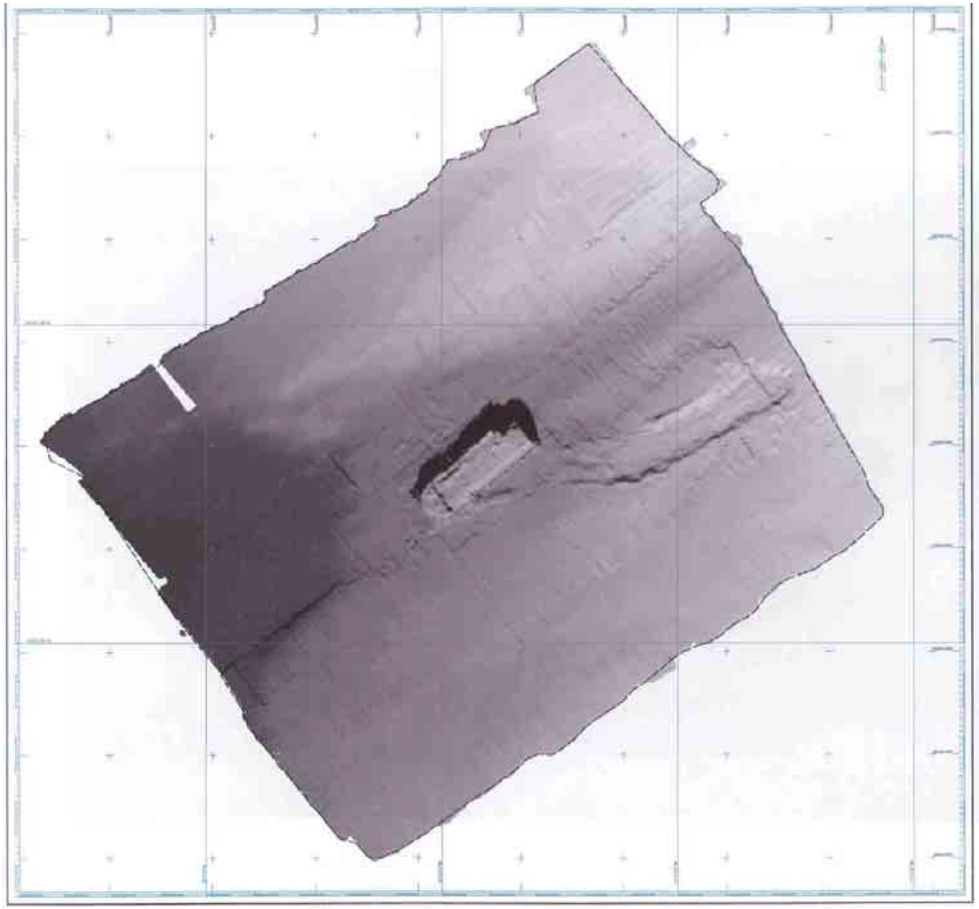


STERN



Accurate Bathymetry

- Data acquisition on the bow wreck area was performed using a Multi-Beam Echo Sounder.
- The ROV “flies” 10-15 metres above the seabed, obtaining high resolution images in an area of about 600x600m.
- From the image obtained, the trace left by the two wrecks from the points of impact with the seabed and its final resting places can be clearly observed.
- This study allows to prepare more accurate 3D models of the wreck, for future work.



Data acquisition for Geo technical studies

- Soil consistency data were taken around the bow wreck with the Mini Core Penetration Tester, on the foreseen locations for the columns of the “Canopy”. Penetrations of up to 10 metres were obtained, showing soft layers of clay lying over consolidated sand.

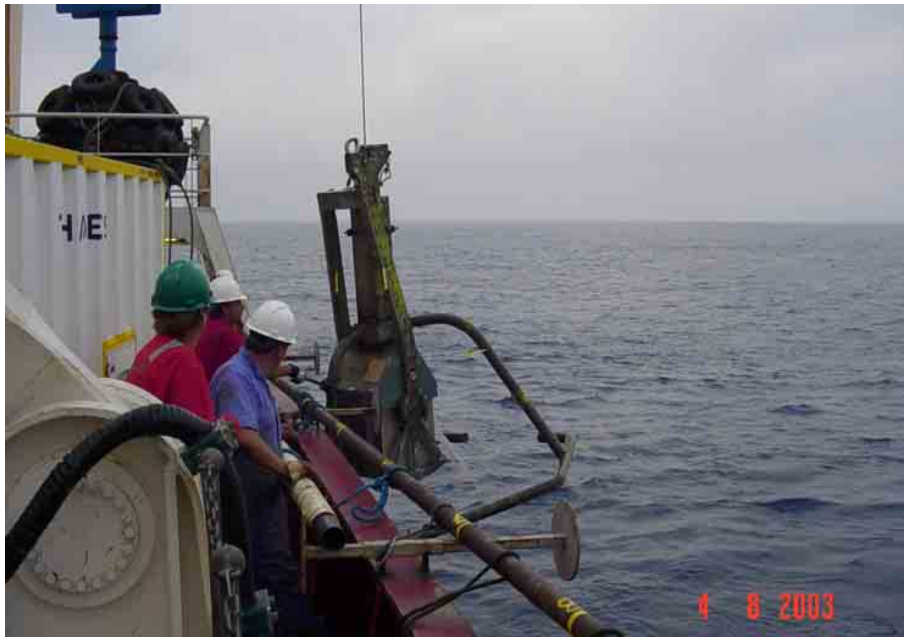
- Three additional penetration tests were carried out around the perimeter of the stern wreck, showing 0.3 to 1.3 m of sand, overlying a very hard, rocky substrate.

Data acquisition for Geotechnical studies (2)

- Additionally, 4 box cores and 7 conventional cores (some 11 to 13 metres in depth), were taken around the bow's wreck.

- Based on these data, on the bathymetry and on the seismic information, a geotechnical study is being carried out to evaluate the requirements for the eventual installation of the "Canopy".

- The geotechnical survey is considered to be a major success at this water depth



Fuel, Water and Seabed Samples

- A number of seabed, fuel and water samples have been taken for environmental studies by the ROVs
- The study of these samples will allow evaluating the viability of using bacteria for the elimination of the fuel that could remain adhered to the walls of the wreck's tanks once the extraction is completed

Sea Testing of Hot Tapping

- Both the Hot Tapping machine and Valve Assembly and the Shuttle Bags were extensively tested onshore. A number of modifications were introduced during this process to fine-tune the behaviour of these prototypes
- Once this phase was concluded, an important sea testing phase was also carried out
- The Hot Tapping Machine and the Extraction Valve were tested at water depths of 150m, 1,000m and over the Prestige wreck itself at 3,800m, during the month of September
- Again during this process, some modifications were introduced to improve the working of the system under these extreme conditions, never attempted before
- Finally, on the night of September 30th, the Hot Tapping machine and the Extraction Valve were installed on the deck of the tank P1 of the bow section of the Prestige
- All six anchor bolts and the main 700mm cutter performed as designed, and the Extraction Valve was left closed awaiting the extraction tests
- Again, this is a major first for the project

Sea Testing of Shuttle Bags

- The Shuttle Bags were also tested in shallow waters, subsequently modified, and tested again
- Further tests were carried out in Vigo (Galicia) during September with the dock barge Enterprise to fine-tune the recovery and stowage operations
- Although bags of these dimensions and even larger have been used for surface transportation of fluids, this will be the first time that these type of bags will be used to extract fuel from a wreck

Dock Barge Enterprise Vessel

- To load the Shuttle Bags at sea and transport them to El Ferrol, the Enterprise, a submersible vessel, which has been modified to make for the safe manipulation of the Shuttle Bags, has been contracted from Dockwise.

Main Characteristics:

- *Type: Semi-submersible Dock Barge*
- *Length: 158m*
- *Breadth: 29m*
- *Draft: 4.5m*
- *Draft when submerged: 11.0m*
- *Water level above main deck, when submerged: 5.7m*

Dock Barge Enterprise Vessel

- Modifications and tests are being undertaken in Rotterdam and Vigo to improve the holding capacity of the stowage of the Shuttle bags.
- The Dock Barge Enterprise is now ready to sail

Modifications done for the manipulation and stowage of the Shuttle Bags

Unloading in El Ferrol and Contingency Plan

- The bags containing fuel will be deposited in the Dry Docks of Izar in Ferrol, where special beds have been prepared to receive them, similar to those built on the Enterprise.
- Once unloaded, the fuel will be transported by road tankers to the Repsol YPF refinery in La Coruña, where a dedicated tank has been prepared and equipped with heaters for its reception and processing.
- Repsol YPF has undertaken a complete identification study of all risks as well as a contingency plan for the collection, transportation and evacuation of the fuel from the bags.
- From the time that the Prestige's hull has been milled until the fuel unloading at port has been completed, an important safety and environmental protection operation with tugs and spill-contention equipment will be active.

5. Confinement by Canopy

(Contingency in case Extraction Fails)

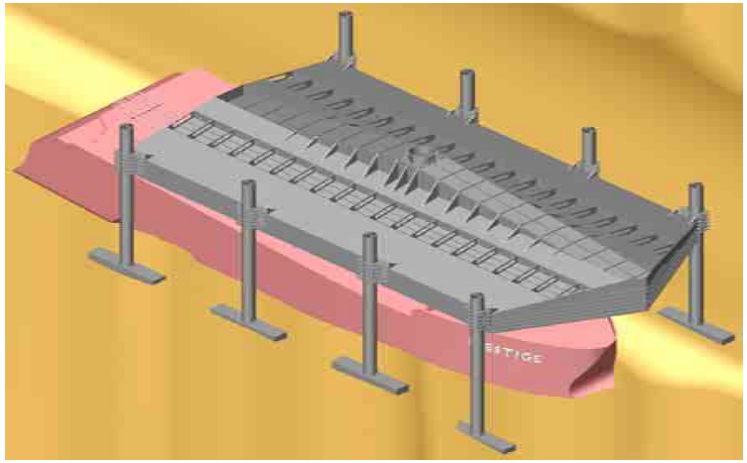
Design Bases

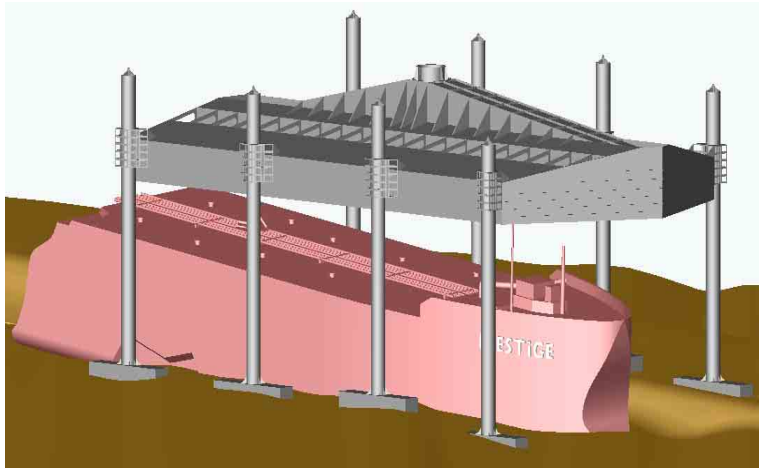
Repsol YPF put together the design bases for the conceptual study, basic engineering and installation viability of the Canopy. The main design characteristics are the following:

- Designed with a fuel collection chamber housing the mechanisms necessary to assist the extraction of fuel (mechanical, electric tracing and injection of solvents).
- Free access to the wreck from all directions by ROV
- Reversible operation with possibility of future recuperation.
- Rigid structure, with complete coverage of the wreck. Minimum life span – 50 years.
- Capable of retaining all fuel remaining in the wreck.
- Once installed, having a weight higher than the floatability of the remaining fuel.
- Inverted V-shape to facilitate the collection of the trapped fuel.

Basic Engineering of the Structure

- The design of the “Marquise” or Canopy has been optimised according to the fuel measurements obtained:
- The length of the “Marquise” has been reduced from 120 m to 103 m since the central tank contains no fuel.
- The volume of fuel to be collected has been reduced from 38,000 m^3 to 20,000 m^3, including a 30% margin.
- The number of legs have been reduced from 10 to 8
- The geotechnical study of the samples taken from the soil survey, necessary for the designing of the bearing columns, have been undertaken in the U.K.
- A model of the “Marquise” (scale 1:5) has been built in the Hydrodynamic Centre of El Pardo for immersion and lowering studies

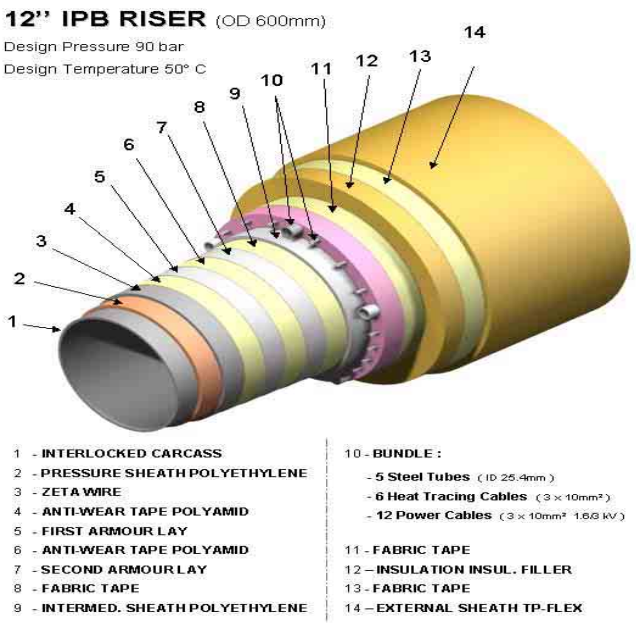


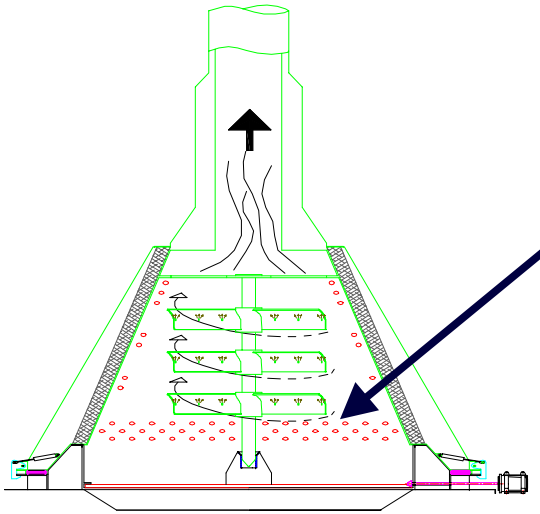


Basic Engineering of the Structure (2)

Continuation of the design in the extraction system:

- **Studies are being undertaken at Huelva University to determine the properties of the fuel with 10, 20 and 30% solvent concentration and heating to 20 - 50ºC.**
- **The optimun design will be established, in terms of solvent to be used, necessary heating and size of the pumping units & riser.**





Chamber for fuel extraction

Basic Engineering of the Structure (3)

Schedule of activities:

- End of Basic Engineering: October 2003
- Call for Offers, construction of the marquee and installation: November 2003
- Installation of the Marquee and opening of the tanks: Summer 2004
- Extraction of the fuel confined in the marquee: Summer 2005

6. Project Execution Programme (Phase I, up to 31/10/2003)

Project Execution, Programme

ID	Task Name
1	**Project Organization**
2	**Marine Operations on the Wreck**
3	**Data Acquisition, Improvement of leak sealing, Pilot test**
4	Engineering
5	Awarding of Contract
6	Development of Eork Class ROVs for 4000m
7	Equipment Mobilization
8	Leak Sealing, Geo Technical Data, Fuel Level Measurement
9	Shuttle Bags Pilot Test
10	**General Data Acquisition**
11	**Analysis of Fuel Properties**
12	Engineering, Laboratory Tests, Processing, Pilot Test
13	**Analysis of the Stability and Integrity of Wreck**
14	**Basis of Design (BoD), Viability, Basic Engineering**
15	BoD and Confinement Viability Study
16	BoD Viability Study of Pumping/Extraction
17	Basic Engineering of Confinement
18	**Recommendation for Final Solution**