INTECSEA
WorleyParsons Group

Construction
Materials Engineering
Capability and Experience

Overview

General

INTECSEA, headquartered in Houston, Texas was formed in 2008 by the joining of heritage Intec with Heritage Sea Engineering to provide a consolidated floating systems risers, pipelines and subsea engineering and construction management services within the global WorleyParsons Group. INTECSEA has established operating offices in Houston, Texas; Kuala Lumpur, Malaysia; Singapore: Delft, the Netherlands; Rio de Janeiro, Brazil; Perth and Melbourne in Australia; and London, UK.

INTECSEA's major areas of expertise include subsea and floating production systems, marine pipeline and riser systems, Arctic pipelines, marine terminal systems, and Arctic structures. Additional areas of expertise include flow assurance and operability, marine surveys, marine operations and offshore equipment design. This document describes INTECSEA's capabilities and experience specific to Materials.

INTECSEA's overall objective is to create confidence and predictability in executing   challenging offshore projects. Through a proactive approach and use of INTECSEA's extensive worldwide experience, INTECSEA is capable of reducing financial and schedule risk, related to materials selection, corrosion management, welding engineering, NDE procurement support, fabrication, installation and operation of offshore developments. INTECSEA's quality system ensures the right administrative and technical procedures are used for project planning, design, procurement, fabrication, testing and commissioning.

INTECSEA's materials, corrosion and welding group specialize in metallurgy, materials selection, welding, corrosion mitigation, cathodic protection design and inspection techniques including automatic ultrasonic testing. This document describes INTECSEA's capabilities and experience specific to materials and welding engineering.

Materials, corrosion mitigation, welding and NDE technology, for deepwater offshore developments is one of INTECSEA's growing business areas. Although many other engineering disciplines and other business areas such as systems engineering, flow assurance and operability, offshore terminals, floating production systems and LNG have been added to the INTECSEA range of project services, materials, corrosion mitigation, welding and NDE is a critical aspect of all marine pipeline and riser projects.

INTECSEA has focused on advancing materials, corrosion, welding and NDE technologies to accommodate for harsh service conditions including, deepwater field developments, arctic conditions, high pressure, high temperature, H_2S and CO_2 containing environments and fatigue loading related to offshore structures, pipelines and steel catenary risers (SCRs). These specialized technologies are now firmly established within INTECSEA's extensive project experience which results in cost effective completion and operation of offshore field developments worldwide.

INTECSEA's capabilities in materials, corrosion, welding and NDE have become well recognized throughout the oil and gas industry and have played an important role in a large number of deepwater developments worldwide. In 1985 INTECSEASEA initiated several joint industry studies to develop solutions for deepwater production in the Gulf of Mexico and the North Atlantic, in which as many as 15 oil and gas companies participated.

In 1996 INTECSEA was selected to set up and manage a materials testing program in over 3500m of water between Oman and India, for the Oman Oil Company. The environmental factors of low temperature, low dissolved oxygen and a unique set of seawater constituents, was expected to impose different sacrificial anode alloy requirements than conventionally used. The testing program consisted of the following:

A test frame was deployed in the sea between Oman and India with anodes attached to determine if the anodes would activate normally. Laboratory testing was also undertaken in a seawater environment which was chemically and thermally identical to measured conditions along the route.

Also, various welding and NDE processes were tested to determine which processes would meet a satisfactory welding and inspection time and to also accurately demonstrate the ability of the NDE systems to detect defects in intentionally flawed welds.

A full scale collapse testing program was also performed as there was no data available for the low D/t and large diameter UOE pipe required for this project. The objectives of this testing program were to establish the actual collapse pressure of the pipeline and to quantify the influence of bending on collapse.

In 1998 INTECSEA set up and managed a materials testing program in the laboratory and also in the Black Sea for Gazprom. The Black Sea seabed contains high levels of H2S, therefore the testing program included:

- sour service testing on the outside of the carbon steel line pipe:
    a) hydrogen pressure induce cracking (HPIC)
    b) stress oriented hydrogen induced cracking (SOHIC)
    c) hydrogen embrittlement (HE)
    d) sulphide stress corrosion cracking (SSCC)
    e) full ring test (includes seam and girth welds and all manufacturing and welding stresses
- fracture analysis
- welding and NDE trials
- mechanical testing and metallography
- additional materials testing programs included aluminum and zinc anodes to determine design parameters required for cathodic protection and anticorrosion coatings including 3 layer polypropylene, fusion bonded epoxy and thermal sprayed aluminum

A detailed collapse testing program was also performed for Gazprom and the objectives were to determine:

- the collapse envelope of the pipeline design and its accurate prediction by numerical methods
- strength reduction characteristics of sour service material and the UOE manufacturing process
- structural reliability of the pipeline system and appropriate design equations were calibrated for future deepwater developments
- strength recovery characteristics of thermal aging during the pipeline coating process
- influences of collapse, bending and buckle propagation on seam and girth welds

Similar testing programs have also been performed more recently on several projects including the BP Mardi Gras project.

Full and small scale fatigue testing has also been set up managed by INTECSEA on several projects including, BP Mardi Gras, Chevron Tahiti, Anadarko GC 518, ENI K2, El Paso Prince and Marco Polo, with the objectives of:

- determining the fatigue life of girth welds for steel catenary risers (SCRs), at low medium and high stress levels
- specifying the allowable misalignment (hi/lo) requirements at weld fit up and after the welding process
- studying the effects of pipe manufacturing (e.g. UOE, seamless, HFIW), pipe diameter and wall thickness
- comparing the performance of pipe to pipe and pipe to forging welds
- studying the effects of welding process (e.g. GMAW, GTAW)
- studying the effects of welding in the 2G (vertical), 5G (horizontal) and 1G (horizontal, pipe rotating) positions and varying the number of welding bugs
- identifying all weld defects prior to and after fatigue testing using automatic ultrasonic testing and determining the level of defect growth
- determine the weld defect acceptance criteria using an engineering critical assessment (ECA)
- studying the effects of surface finish on line pipe

INTECSEA has gained extensive experience on the most challenging deepwater projects worldwide, to date, and knows the technical and construction risks associated with such projects and how to mitigate these risks.

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Materials Engineering Project List

INTECSEA has emerged as an industry leader in deepwater materials selection, corrosion management, welding engineering and NDE services and has been instrumental in a number of world class field development projects including:

- Oman Oil Company, Oman to India
- Gazprom, Blue Stream, Russia to Turkey
- Burullus Gas Company which is a consortium of British Gas, Edison International and Egyptian General Petroleum Company, Scarab/Saffron and Simian /Sienna, Egypt
- BP Amoco, King and King's Peak, Gulf of Mexico
- BP, Northstar, Alaska
- TotalFina Elf, Canyon Express, Gulf of Mexico
- Exxon, Diana, Gulf of Mexico
- Exxon, Mobile Bay, Gulf of Mexico
- ExxonMobil, Marshall Madison and Mica, Gulf of Mexico
- Chevron Insulated Offshore Pipeline Study
- Chevron, Tahiti, Gulf Of Mexico
- Chevron, Agbami, West Africa
- Chevron, Blind Faith, Gulf of Mexico
- Amerada Hess, Northern Block G, West Africa
- El Paso, Prince/Marco Polo, Gulf of Mexico
- ENI, K2, Gulf of Mexico
- Clough Offshore, Mutineer Exeter, Australia
- BP, Horn Mountain, Gulf of Mexico
- BP, Mardi Gras, Gulf of Mexico
- Petrobras, Guanabara Bay, Brazil, South America
- British Gas, Medgaz, Algeria to Spain, Europe
- AES Corporation, Ocean Express, Bahamas

- Unocal, West Seno, Indonesia
- Shell, Bonga, West Africa
- Cairn Energy, KG DWN-98/2, Australia
- Pioneer, Oooguruk, Alaska
- Pioneer, Olowi, West Africa
- Clough Offshore, G1 and GS15, India

Materials Engineering Services

As a minimum, INTECSEA considers the following to be critical, for the successful execution of any onshore or offshore project:

- corrosivity, taking into account start up and shutdown conditions
- design life
- materials selection and welding technology
- failure probabilities, failure modes and failure consequences for human health, environment and safety
- NDE during the fabrication of components and during operation
- corrosion monitoring

INTECSEA is able to optimize on the materials selection taking into account investment and operational maintenance costs, such that overall costs are minimized while providing acceptable safety and reliability.

INTECSEA has provided materials and welding support for flowlines, risers and subsea systems, to operators and national oil companies worldwide, for over 20 years.

INTECSEA is very familiar with all national and international codes and standards including, Shell DEPs, BP, ASTM, AWS, BS, Norsok, DNV, ASME, ISO, NACE, EEMUA, etc.

INTECSEA can provide personnel for onshore/offshore project visits worldwide, assist with troubleshooting and provide training and mentoring of engineers/technicians.

INTECSEA’s Specialist Areas of Expertise Include:

- Materials selection for flowlines, steel catenary risers (SCRs) and subsea equipment (wellheads jumpers, and manifolds) specifying material chemistry, mechanical property requirements, dimensional tolerances and inspection requirements
- Specifying requirements for forgings (including J-lay collars and flexjoints), induction bends, anodes (tapered, use of doubler plates, PU tapers), bolts, nuts and gaskets
- Specification preparation for all material components including line pipe and subsea equipment
- INTECSEA has gained extensive metallurgical experience using carbon steel, high strength low alloy steels, austenitic, martensitic (13 Cr) and duplex stainless steels, titanium alloys, clad and lined pipe and other corrosion resistant alloys. In particular, INTECSEA has gained extensive experience regarding alloying elements and microstructures of these alloys

- Good in-house knowledge of line pipe mill capabilities worldwide and the various manufacturing processes (i.e. DSAW, seamless, HFIW, Clad, and Pipe in Pipe systems)

- Failure analysis, metallography (including optical, scanning and transmission electron microscopy)

- Addressing low or high temperature material requirements and relevant testing

- Experience with identifying and managing the following types of failure mechanisms: fatigue, corrosion fatigue, corrosion failures, stress corrosion cracking, ductile and brittle fractures, hydrogen embrittlement, creep and stress rupture

- Assessing corrosion rates and defining the requirements for inhibition, internal protection or the selection of corrosion resistant alloys

- Forms of corrosion - galvanic, crevice, pitting, preferential weldment corrosion, corrosion fatigue, inter/intragranular, SCC, SSC and HPIC, SOHIC, MIC

- Specialist materials testing and specifying acceptance criteria for strain aging, fatigue, weldability, collapse and sour service (HISC, SOHIC, HE, SSCC and the full ring test)

- Performing cathodic protection design work for flowlines and SCRs; Utilization of attenuation calculations for the cathodic protection (CP) design of SCRs and insulated and non-insulated flowlines

- Determining corrosion rates in CO2 containing environments, using programs such as deWaard/Milliams and NORSOK

- Determining a materials susceptibility to H2S bearing hydrocarbon service using NACE MR 0175 and EFC 16

- Corrosion theory, anodic/cathodic reactions, polarization diagrams, Evans diagram, principles of cathodic protection, over potentials, galvanic series/couples

- Coatings selections for pipelines, risers, subsea structure, topsides and field joints, e.g. coal tar, FBE, epoxies, polyolefinics, 3 layers, PU, high temperature systems, insulation; Coating testing (laboratory and field) – cathodic disbondment, impact, high temperature, high pressure, collapse, sour service

- Welding requirements for flowlines, SCRs, and subsea equipment, including welding specification and WPS and WPQ work; INTECSEA has played a major role on many projects, helping contractors develop their welding procedures

- Good in-house knowledge of all installation contractors welding processes and procedures for onshore and offshore welding (including Reel, J and S lay installation methods)

- Procedures for optimizing weld alignment, in particular for SCRs; this includes ID machining and accurate misalignment (hi/lo) measurement, prior to welding

- Advice during design on the weldability of materials, welding design, fracture toughness design criteria and the extent of pre and post-weld heat treatment

- Allowable defect acceptance criteria API 1104 Section 9 or Appendix A or ECA in accordance with BS 7910, FLAWPRO or DNV/SINTEF guidelines

- Specialized testing API RP 2Z, single edge notch tension (SENT)
- Weld alignment including machining, measuring and sorting of line pipe

Materials Selection

Material Specification Preparation

INTECSEA's detailed materials specifications have been utilized by all the major operators worldwide and the specifications are periodically updated to incorporate new technologies, lessons learnt and code revisions. As an example, the following topics would be addressed in INTECSEA's detailed line pipe specification.

INTECSEA considers the following items to be critical when specifying line pipe requirements:

- criticality of application (water depth, fatigue, Arctic)
- service conditions (sweet or sour)
- installation method (J, S or Reel Lay)
- diameter/wall thickness requirements
- manufacturing process (DSAW, seamless, HFI, clad)
- steel chemistry and heat treatment
- mechanical property requirements (tensile, hardness, charpies, CTODs)
- dimensional tolerances (e.g. wall thickness, OOR)
- on destructive evaluation
- pipe mill capabilities

Metallurgical Expertise

INTECSEA has gained extensive metallurgical experience using carbon steel, high strength low alloy steels, austenitic, martensitic (13 Cr) and duplex stainless steels, titanium alloys, clad and lined pipe and other corrosion resistant alloys. In particular, INTECSEA has gained extensive experience regarding alloying elements, heat treatment and microstructures of these alloys.

INTECSEA can provide guidance and advice on some of the more important subject matters highlighted below, for the more common alloys used in the offshore oil and gas industry.

Failure Analysis

INTECSEA has experience with identifying and managing the following types of failure mechanisms; fatigue, corrosion fatigue, corrosion failures, stress corrosion cracking, ductile and brittle fractures, hydrogen embrittlement, creep and stress rupture.

The most common causes of these failures include assembly errors, manufacturing defects, improper maintenance, design errors, poor material selection, incorrect heat treatment, poor quality assurance and control.

INTECSEA has experience in and can manage the following failure analysis activities:

- determination and identification of failure mechanisms
- materials analysis
- metallography (including SEM and TEM work)
- fitness-for-purpose analysis
- remedial and repair work
- on-site testing

Procurement Support Capabilities

The objectives of INTECSEA's procurement support services are to ensure that the selected manufacturers/suppliers have adequate technical integrity, that the various procedures meet all project requirements and that all the fabrication activities are carried out in a satisfactory manner, meeting the requirements stated in the applicable project documents.

INTECSEA's procurement support would typically include the following:

- review of technical bid documents
- attend pre-production audits at the pipe mill or other fabrication sites in order to ensure that all processes and systems are capable of consistently producing line pipe and components according to the project specifications
- review manufacturing procedure specifications (MPS), quality plans, inspection and test plans (ITP), welding procedures (WPS/WPQs), forging and heat treatment procedures, NDE procedures, coating procedures, material traceability systems, productions plans and schedules, QA/QC procedures and other various documentation used as the basis for manufacturing of various components
- resolve any technical problems, non-conformances and fabrication deviations

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Corrosion Management Experience

The corrosion management expertise offered by INTECSEA is listed below:

- cause and effects of corrosion
- causes of failure to pipelines, risers and subsea equipment
- forms of corrosion - galvanic, crevice, pitting, preferential weldment corrosion, corrosion fatigue, inter/intragranular, SCC, SSC and HIC, SOHIC, MIC
- internal and external corrosion mechanisms on pipelines, subsea structures/components, topsides components, piping
- corrosion theory, anodic/cathodic reactions, polarization diagrams, Evans diagram, principles of cathodic protection, over potentials, galvanic series/couples
- cathodic protection systems for subsea components, offshore pipelines, offshore structures and onshore pipelines and tanks and terminals
- chemical inhibition recommendations
- ensuring that compatible coatings are used
- specifying and checking coatings before, during and after application
- coatings selections for pipelines, risers and subsea structures and topsides, eg coal tar, FBE, polyolefinics, 3 layers, PU, high temperature systems, insulation
- coating testing (laboratory and field) – cathodic disbondment, impact, high temperature, high pressure, collapse, sour service
- selecting, specifying and checking cathodic protection monitoring systems and site surveys
- surface preparation requirements/methodologies and coatings application field joint coating materials selection, design and application methodologies, corrosion monitoring by coupons, ER, LPR probes
- hydrate prevention (methanol)
- dehydration systems (MEG/TEG)
- dew point control

Corrosion Assessment

To perform a thorough corrosion assessment of a reservoir, INTECSEA's corrosivity evaluations require detailed information on the following:

- CO2 and H2S content
- Oxygen content and content of other oxidizing agents
- Operating temperature and pressure
- Organic acids, pH
- Halide, metal ion and metal concentration
- Velocity, flow regime and sand production
- Biological activity
- Condensing conditions
- Top of the line corrosion (TOL)

Coatings Technology

The coating system is the first layer of protection against external corrosion and is comprised of primary and field joint coatings. A cathodic protection system is also provided as back up to account for deficiencies in the coating such as holidays during coating application, damage to coating during transportation and installation and mechanical damage or other coating degradation during operation. Surface preparation is critical for successful coating application.

When INTECSEA selects anti-corrosion coatings, the following items are taken into consideration:

- design life
- service temperature range
- impact and abrasion resistance
- tensile strength, elongation, and flexibility
- adhesion/resistance to disbonding
- flexibility
- resistance to chemical and biological deterioration
- compatibility between parent coatings and field joint coatings

- compatibility with cathodic protection system requirement that the volume resistivity of coating shall not exceed 1.0x104 ohm·cm.)
- thermal expansion
- swelling and shrinking by gas and by liquid absorption
- decompression resistance in high pressure oil/gas systems
- Cathodic protection shielding
- track record
- Use of hydrophobic field joint materials to increase allowable weld defect sizes
- required coating to obtain low coating breakdown factors
- accessibility for coating operation

Cathodic Protection Design Steps

The design steps INTECSEA follow, to size and space sacrificial anodes are to calculate the following:

- mean current demand for cathodic protection
- final current demand for cathodic protection
- total anode net mass to meet mean current demand
- total anode current output to meet final current demand
- distribution of anodes

From these calculated design steps the anode mass and the number of anodes required can be determined assuming the following information is available:

- design life
- burial conditions
- selected anode material properties (deepwater chemistry, indium activated)
- coating selection and breakdown assumption (eg insulation on flowlines and SCRs)
- anode dimensions
- current density requirements (varying with time and temperature)
- environmental properties such as resistivity, which varies with salinity and temperature

Corrosion Mechanisms

INTECSEA has experience in preventing pitting, crevice, galvanic, uniform, erosion, from occurring, by careful materials selection and design.

CO2 Corrosion Modeling

INTECSEA's internal corrosion analysis is performed in accordance with deWaard/Milliams or NORSOK. The factors that govern the corrosion rate as defined in the model are:

- Pressure
- Temperature
- CO2 Content
- Water Content
- Flowrate (shear rate)
- pH

H2S (failure mechanisms)

Sulphide stress cracking is dependent on the following variables:

- metal chemical composition, strength, heat treatment and microstructure
- hydrogen ion concentration (pH) and total pressure
- hydrogen sulphide concentration
- total tensile stress
- temperature
- time

The three main types of cracking which can occur as a result of high H2S levels are:

- sulphide stress cracking
- stepwise cracking
- stress oriented hydrogen induced cracking (SOHIC)/ soft zone cracking (SZC)

The documents INTECSEA used to determine the severity of sulphide stress cracking are NACE MR 0175, ISO 15156 and EFC 16.

Corrosion Monitoring

INTECSEA can set up corrosion monitoring requirements and some of the more important aspects of corrosion monitoring are specified below.

Monitoring can give advance warning of potential problems in the event of maloperation or changes in the corrosivity of the product fluids such as that from carbonic acid.

Condition monitoring of internal surfaces may be carried out by using a combination of the following methods:

- intrusive probes and coupons to monitor erosion and corrosion including; weight loss coupons, electrical resistance (ER) probes, linear polarization resistance probes, galvanic probes and sand probes
- wall thickness measurements (ultrasonic/radiography)
- chemical analysis of samples from the product
- visual inspection
- non-intrusive probes such as the clamp on sand monitor based on passive acoustics
- fingerprint signature method (FSM)

Chemical Inhibition

There are numerous chemicals and corrosion inhibitors available on the market hat will enhance production, flow assurance and reduce corrosion rates in carbon steel to an acceptable level.

The following chemicals are considered for most offshore field developments and INTECSEA has the experience to help specify project specific requirements:

- methanol: for start up and shut down conditions only
- low dose hydrate inhibitor: for continuous hydrate remediation, that occurs in late life, following qualification
- scale inhibitor
- asphaltene inhibitor
- demulsifier
- O2 scavenger (for water injection)

- biocide (for water injection)
- corrosion inhibitor (filming, amines, etc.)

Welding Engineering Experience

Welding Capabilities

INTECSEA's technical requirements for the fabrication of components are detailed in specifications and these specifications cover welding procedures, qualification of welders, fabrication requirements, dimensional tolerances, inspection and testing requirements for flowlines, SCRs and subsea equipment.

INTECSEA has played a major role on many projects, helping contractors develop their welding procedures. INTECSEA has provided fabrication and welding engineering support on the most challenging deepwater projects to date.

Some of the services INTECSEA can offer regarding welding engineering are highlighted below:

- input to the design and construction of offshore structures, pipelines and chemical plants from preliminary design through to support of the construction team
- advice during design on the weldability of materials, welding design, fracture toughness design criteria and the extent of pre and post-weld heat treatment
- development of material, fabrication and NDE specifications
- conducting technical bid assessments of manufacturers and fabricators
- allowable defect acceptance criteria API 1104 Section 9 or Appendix A or ECA in accordance with BS 7910, FLAWPRO or DNV/SINTEF guidelines
- specialized testing API RP 2Z, single edge notch tension (SENT)
- pre and post weld measurement including use of TOFD for go/no go check on completed welds
- weld alignment including machining, measuring and sorting of line pipe
- technical audits of vendors or fabricators
- review of vendors or contractors welding, fabrication and non-destructive testing documents
- assignment to fabrication, construction and installation sites to co-ordinate fabrication activities
- evaluation of weld and heat affected zone microstructures
- assessment of failures and rectification and prevention strategies
- ensure the quality of all welding operations used in onshore and offshore fabrication, through identifying appropriate welding procedures, welder qualifications and inspection and test methods
- ensuring compatibility between weld metal and base material for piping systems for corrosive hydrocarbons

- weld overlay requirements for crevice corrosion prevention taking into account, maximum iron content permitted, corrosion resistant alloys and minimum thickness requirements
- validate fabrication and construction by NDE methodologies including automatic ultrasonic testing
- serve as a technical expert in contractual matters between purchaser and contractor
- specify the minimum requirements for welding operations which will be subject to third party verification/certification
- internal line-up clamps

Welding Process Selection

INTECSEA has the expertise to specify which welding processes are most suitable, considering the application. INTECSEA has gained a wealth of experience over the last 20 years, with the following processes:

Onshore welding: GTAW (root and hot pass) plus SAW (fill and cap), GMAW (root and hot pass) plus SAW (fill and cap), GMAW

Offshore welding: GMAW, GTAW (root and hot pass) plus GMAW (fill and cap)

For recent SCRs, the pulsed gas metal are welding (PGMAW) process has been used because it reduces copper pick up from backing shoes and is less prone to weld defects when compared to the short arc welding process. The combination of GMAW and SAW welds, have shown poor fracture toughness and fatigue performance on recent projects.

The mechanized GMAW process is the most widely used welding process currently used offshore mainly due to good process control due to mechanization, productivity, track record. Some limitations of this process include, lack of fusion (planar defects) and copper contamination from contact tips and copper backing shoes.

The highlights of the GMAW, GTAW, SAW and SMAW welding processes are given below and INTECSEA is very aware of the advantages and disadvantages of each process.

Non-Destructive Evaluation (NDE) Experience

INTECSEA can provide expert advice in the following areas for NDE:

- most suitable inspection method for your needs both technically and economically (e.g. criticality of inspection, flowlines versus SCRs)
- correct interpretation of data
- verifying specification requirements have been met
- setting up inspection plans
- evaluation of performance of inspection equipment especially for critical application such as SCRs and top tension risers (e.g. system qualification in accordance with DNV OS F101) in particular for automatic ultrasonic testing (AUT)
- multi-probe systems (SPS, RTD, Weldsonics) versus phased array systems (RDTech)
- probability of detection
- defect sizing accuracy
- specifying AUT requirements for heavy wall thicknesses > 25mm
- special requirements for SCRs and top tension risers including wall thickness restrictions
- use of time of flight diffraction (TOFD) to supplement shear wave inspection
- 3rd party verification offshore

NDE Methods

- NDE can be defined as an inspection method that does not adversely affect the item being inspected. NDE is usually specified to:
- ensuring quality during manufacture by identify imperfections and defects
- in-service inspection with the objective of detecting defects due to physical deterioration of a component, such ad crack propagation
- critical defect assessment including fitness for purpose and fracture mechanics calculations

There are 6 NDE methods commonly used in the offshore oil and gas industry and these are:

- visual – surface inspection method
- liquid penetrant (LP) – surface inspection method
- magnetic particle inspection (MPI) – surface and slightly sub-surface inspection
- ultrasonics (including AUT) – volumetric inspection method
- eddy current – primarily surface inspection method
- radiography (RT) – volumetric inspection

To ensure accuracy in the interpretation of data, essential prerequisites include:

- NDE operator training, certification approval, track record (ASNT Level 2)
- NDE procedure approval
- well maintained and calibrated equipment
- reporting procedures and formatting of data

Defect Sizing Accuracy

A major problem with AUT systems is that each potential user runs their own validation program using their own equipment and scope of work. This leads to differences of opinion regarding the AUT systems capabilities regarding defect sizing. For example height size accuracies vary from as little as +/-0.5mm to +/-2mm and these discrepancies can be explained by:

- inspection procedure
- design of calibration blocks
- differences in validation methodology
- type and shape of defects inspected
- material used for validation program (eg. grain size variations, attenuation variations)

It is important to highlight that the significance of a defect in a girth weld depends on:

- position in the weld
- pipe wall thickness

- properties of the material in which the defect lies (yield strength mismatch)
- service conditions of the pipeline

Some general rules of thumb are:

Surface breaking defects are roughly twice as severe as the same size embedded defects.

Weld reinforcement makes embedded defects far less critical for the structural integrity than surface breaking ones; however the beneficial effect of the weld reinforcement on the weld performance vanishes for surface breaking defects.

Some of the main advantages of using AUT in combination with an engineering critical assessment are:

- reduces the amount of unnecessary weld repairs
- reduction of weld reject rates
- ability to size the through-thickness dimension of flaws

Phased Array versus Multi-Probe

Phased array (PA) involves the use of a single multi-element probe (usually 64 elements) on each side of the weld to emulate the many single crystal probes used singly and in tandem to inspect weldments on the more common multi-probe systems.

Currently, phased array systems are being used well within their potential to simply emulate multi-probe systems. Phased arrays have additional capabilities that are not currently utilized (rasta scans and even sweeping angle scans.

Time of Flight Diffraction

Time of Flight Diffraction (TOFD) is often added as an additional inspection method. TOFD is utilized to collect additional information such as evaluating, characterizing and locating indications with unaccepted orientations and/or defect locations. It is implemented for accurate sizing and provides a safety net.

TOFD utilizes two angle compression wave probes in a pitch-catch arrangement. The wave probes are placed on both sides of a weld and aimed at the same point in the weld volume. The weld is then flooded with ultrasound using a single uni-axial scan pass along the weld length. Based on the measures, TOFD determines the arrival times of the various signals. In this way, TOFD can effectively determine the height, length and location of any weld defects.

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Materials Engineering Project Experience

INTECSEA has provided materials, corrosion, welding and non destructive evaluation expertise on the following projects:

Project Name/Location	Client	Project Description	Finish Date
Frade Field Development	Chevron	Materials specifications. Welding and NDE support	Ongoing
Mardi Gras Deepwater Transportation Systems	BP	Developed new technologies for full scale collapse, and fatigue testing. Developed welding and NDE procedures	Ongoing
Nikaitchuq	Kerr McGee Gas Corporation	Materials Specifications Procurement Support Bid Reviews	Ongoing
Nsiko	Chevron	Materials Specifications	Ongoing
Kizomba Satellites	ExxonMobil	Materials Specifications	Ongoing
Blind Faith Field Development Gulf of Mexico	Chevron, BP	Material specifications. Fatigue testing. Welding and NDE trials. ID boring of line pipe	2008
Agbami Field Development Project Offshore Nigeria	Chevron	Materials selection. Corrosion management. Welding engineering. Subsea equipment selection.	2008
Shenzi	BHP Billiton Petroleum	Materials Specifications Procurement Support Welding Engineering Troubleshooting	2008
Thunder Hawk	Murphy Exploration and Production Company	Materials Support	2008
Northern Block G Development	Amerada Hess	Materials and Procurement Support	2007
Northern European Gas Pipeline	Petergaz	Detailed Materials Specification Supported Petergas in Moscow technology Transfer Activities	2007

Project Name/Location	Client	Project Description	Finish Date
PSS	Petrobras	Materials Selection Material Specifications	2007
Oooguruk	Pioneer Natural Resources, Alaska 1m	Materials and Welding Engineering Procurement Support Bid Review	2007
Deep Panuke	Encana Corporation	Materials Selection Specification Preparation Procurement Support	2007
K2 Field Development Production Facilities Gulf of Mexico	ENI Petroleum	Materials selection. Corrosion management. Procurement and installation support. Bid reviews	2004
Mutineer Exeter Subsea Development	Clough Offshore	Corrosion assessment. Materials selection. Procurement support	2004
Algeria to Spain Gas Pipeline	MEDGAZ consortium partners	Front end engineering, design, pipeline design and preparing the EPIC bid packages.	2004
Ocean Express Pipeline	AES Corporation	Materials specifications including non-magnetic requirements for the line pipe (stainless steels)	2004
Olowi Project – Pipeline Feed	Pioneer Resources Gabon-Olowi, Ltd.	Sour service requirements for materials specifications	2004
Independence Hub (MC920) Subsea Field Development	Anadarko Petroleum Corporation	Prepared tender documentation for all major components. Reviewed and pre-qualified vendor equipment for record depths.	2004
Green Canyon 518 Subsea Development	Anadarko	Pipe in pipe design. Fatigue testing. Materials and welding support.	2004
El Paso Marco Polo and Prince Field Development	El Paso Energy Partners	Detailed design of SCRs. Materials specifications. Installation support	2003
Scarab/Saffron and Simian/Sienna Subsea Development Offshore Egypt	Burrullus Gas Company	Materials specifications. Procurement support. Subsea equipment supply.	2003

Project Name/Location	Client	Project Description	Finish Date
West Seno Phase II, Pipeline Design	UNOCAL/Sea Engineering	Prepared materials specifications. Performed ECAs for all SCRs	2002
Gazprom Blue Stream Pipeline Project Southern Russia	Gazprom	Laboratory and field testing of coatings and sacrificial anodes. Sour service testing. Collapse testing. Welding trials including electron beam.	2002
Canyon Express Project Gulf of Mexico	TotalFina Elf	Materials specification preparation. Procurement support. Equipment qualification. Construction management.	2001
Mica and Marshall-Madison Flowline Project Gulf of Mexico	ExxonMobil Development Company	Materials selection. Corrosion management. NDE requirements.	2001
Horn Mountain Pipeline Gulf of Mexico	BP, formerly VASTAR Resources Inc.	Materials specifications. Fatigue testing. Cost estimates.	2001
PETROBRAS Guanabara By PE-3 Pipeline	PETROBRAS	Cathodic protection design using impressed current. Materials selection for relatively high temperatures. Upheaval buckling and fatigue issues resolved.	2001
Bonga Field Development	Stolt Offshore Services	Materials selection for water injection and gas export lines. Set up fatigue testing programs.	2001
Northstar Pipeline Project Alaskan Beaufort Sea coast	BP Exploration, Alaska	Arctic offshore and overland materials specifications. Full scale pipe bend test program.	1999
Diana Pipeline Project Gulf of Mexico	Exxon Company	Corrosion management. Fabrication and construction procedure reviews. Welding qualification program.	1999
Oman to India Pipeline Route Survey	Oman Oil Company	Laboratory and field testing sacrificial anodes. Welding and NDE trials. Collapse testing.	1998
King/King's Peak Pipeline Study Gulf of Mexico	Heerema Marine Contractors	Materials take offs and cost estimates. Developed method to control hi/lo. Pipe in pipe insulation material requirements	1998

Project Name/Location	Client	Project Description	Finish Date
Garden Banks 235 Subsea	Louisiana Land and Exploration Company	Materials and equipment specifications. Construction management.	1998
Mobile Bay Flowline Gulf of Mexico	Exxon Company	Specifying insulated pipe in pipe requirements. Field joint design. Materials, fabrication and installation specifications.	1997
Insulated Offshore Pipeline Study	Chevron Petroleum Technology Company	Study of non-jacketed and vacuum insulation systems for future use.	1995

Project Resumes

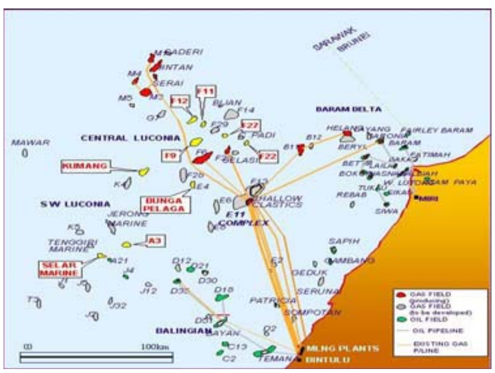
- Exxon Mobil Bay CRA Flowline Project
- BP Alaska Northstar Pipeline Project
- Canyon Express Project
- Anadarko Green Canyon 518 Subsea
- ChevronTexaco Blind Faith Field
- Gazprom Blue Stream Pipeline Project
- Umm Shaif Pipeline & Cable
- Chevron Benchamas Field Development
- CNOOC PY34-1 Gas Field Development-Pipeline Corrosion Control Study
- ExxonMobil Blackback and Kingfish
- Kumang
- Towngas - Pipeline Integrity Study

Project Profile

Project:	FEED Services for Kumang Cluster Development Project
Client:	Petronas Carigali Sdn. Bhd.
Location:	Offshore Sarawak, Malaysia
Scope:	FEED Services for Kumang Cluster Development Project
Timeframe:	March - October 2007
Project Value:	

Phases:

1	2	**3**	4	5
Identify	Select	Define	Execute	Operate



Phase 1 consists of F9, Kumang and Kanowit fields. FEED shall comply with the requirements of the field development concept for Kumang Cluster Development Project. The field area development concept adopts Kanowit as a Central Production Platform (CPP) for Kanowit field and drilling platforms for F9, Kumang and Kanowit fields. The 28" x 190 km long dehydrated gas export pipeline to MLNG- 2 shall be designed to transport 500 MMscfd gas and about 22,000 bbl/d condensate with 10% upward margin to meet stream day peaking requirement.

Kanowit (KAKG-A), shall be a Central Processing Platform (CPP), while Kumang (KUJT-A), F9 (F9JT-A) and Kanowit (KAJT-A) shall be drilling satellites suitable for both Jack-up and Tender Assisted Rigs. The drilling satellites shall be designed unmanned operation with minimum processing equipment and utilities and interconnecting pipelines.

First Gas from Phase 1 Development is targeted by First Quarter of the year 2010.

SCOPE OF SERVICES:

- Feasibility study for sub sea Y junction
- Selection of high line pipe grade (X70)
- Interfacing with proposed future pipeline to OGT

Project Profile

Project: CNOOC PY34-1 Gas Field Development - Pipeline Corrosion Control Study

Client: CNOOC Research Center

Location: Panyu/Huizhou Gas Fields

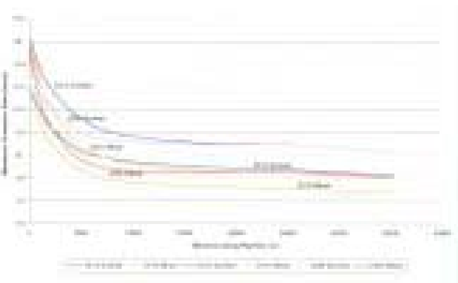
Scope: Use of CRA and Hydrate Inhibitor Studies

Timeframe: 2003

Project Value:

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



The Research Centre, CNOOC Limited China have commissioned a study on internal corrosion for a planned 37 km, 12" OD submarine pipeline from a subsea development (PY34-1) to a platform (PY30-1). The gas will be wet with a considerable amount of CO2 which will make it corrosive to carbon steel. WorleyParsons have been awarded a contract to perform the Corrosion Control Study for the project pipeline.

The objectives of the study have been to establish the philosophy and required materials for the 12" OD, 37 km long submarine pipeline with particular reference to internal corrosion mitigation.

The study is to examine pipeline requirements in terms of material grades and wall thicknesses/ corrosion allowance having first established the requisite design data. The selection of a combination of carbon steel/inhibitor and the use of Corrosion Resistant Alloys (CRA's) is supported by a life cycle cost analysis and project cost estimates

SCOPE OF SERVICES:

- To define the philosophy for internal corrosion mitigation of the pipeline and to perform the necessary engineering and life cycle cost analysis, in order to select materials for the pipeline.
- Corrosion protection measures will take into account all aspects of any possible line pipe corrosion from initial transportation and storage, through construction, precommissioning and operation of the pipeline

INTECSEA
WorleyParsons Group

Project Profile

Project: Blackback and Kingfish Fuel Gas Line - Offshore Installation

Client: ExxonMobil

Location: Bass Strait, Australia

Scope: Owners Engineer

Timeframe: 1998 - 1999

Project Value: AU$ 0.1M

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate

Blackback
The Blackback facilities comprised three subsea completions in a water depth of 402m, connected in a daisy chain formation and controlled from Mackerel platform 18 km away. A 200mm pipeline inside a 300mm diameter carrier pipe was laid between Mackerel platform and the Blackback facilities using the 'Apache' reel-lay vessel in December 1998 to January 1999. The pipeline was wound onshore onto a reel in eight km lengths and then unreeled into position at sea.

Kingfish Fuel Gas Line
The 54 km, 150 NS Kingfish Fuel Gas Pipeline was installed to provide fuel-gas and gas-lift gas from MLA platform to the three Kingfish platforms; KFA, KFB and WKF. The pipeline was installed using the 'Apache' reel-lay vessel in January 1999.

The 'CSO Marianos' DSV (diving support vessel) was used to install the platform risers and interconnection tie-in spools in August 1999. The installation included Sub Sea Isolation Valves (SSIVs) adjacent to the MLA, KFB, KFA and WKF platforms.

SCOPE OF SERVICES:

The WorleyParsons scope of work included:

- Project management during DSV and Reel Vessel contractor's offshore engineering and procedure development
- Preparation of Pipeline licences for submission to government
- Preparation of Risk Assessment resolution sheets for close out of offshore installation hazards
- Preparation of specifications and scope of work for KFFG Sub Sea Isolation Valves (SSIVs)
- Preparation of specifications and scope of work for Marine Warranty Surveyor Services for offshore installation engineering and procedures
- Review of installation contractor's installation manuals
- Esso representative and Offshore supervision of the installation contractor on board DSV (diving support vessel) and on board 'Apache' reel-lay vessel
- Esso representative and Offshore supervision of the installation contractor on board MLA platform during KFFG pipeline flooding.

INTECSEA
WorleyParsons Group

Project Profile

Project: Chevron Blind Faith Field Development

Client: Chevron

Location: Blind Faith Field, Gulf of Mexico

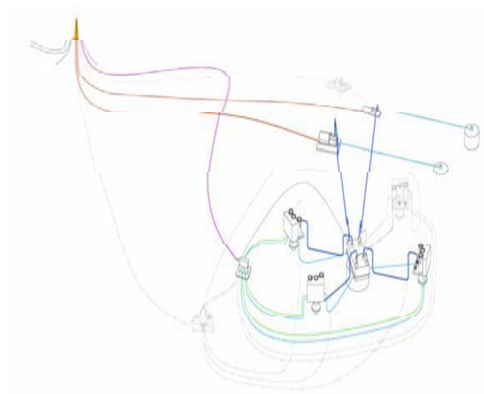
Scope: INTECSEA assisted Chevron in evaluating field development options and supported their steps through the concept selection process, FEED and detailed design.

Timeframe: March 2004 - Ongoing

Project Value: USD 1.9 million

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



Chevron's Blind Faith field is located in Mississippi Canyon Block 696 at a water depth of approximately 7,000 ft. Blind Faith is an oil system with a high pressure reservoir (approximately 12,500 psi WHSITP) and the potential of high temperatures at the wellhead in excess of 250° F. The high pressure and high temperature production in 7,000 ft water depth make Blind Faith a technically challenging project. In fact, these parameters put design requirements at the leading edge of industry supplier capability.

SCOPE OF SERVICES:

INTECSEA assisted Chevron in evaluating field development options and supported their steps through the concept selection process. Following concept selection, INTECSEA worked as part of Chevron's FEED Team to develop the technical requirements for the Blind Faith subsea system. INTECSEA provided support as part of the Client Team managing detailed design and construction. INTECSEA provided:

- In pre-concept, a detailed cost estimate
- In concept selection, identification of viable field development options, development of these options for evaluation, detailed cost estimates for each option, evaluation of the options and selection support to be carried into FEED
- During FEED, INTECSEA developed functional and technical requirements for the subsea systems and provided bid support during bid evaluations
- In the execution phase, INTECSEA is providing technical support, procurement management, and construction oversight

INTECSEA's scope of work includes all subsea systems: trees, manifolds, controls, umbilicals, jumpers, PLETs, flowlines and risers.

INTECSEA provided support for evaluation of hull structure studies and flow assurance and evaluated some key technologies being considered for the Blind Faith Field Development. Studies were performed for:

- Artificial lift
- Subsea multiphase pumps
- Subsea multiphase flowmeters
- High Integrety Pipeline Protection Systems (HIPPS)
- Electrical flowline heating
- Subsea distribution for chemical injection

INTECSEA
WorleyParsons Group

Project Profile

Project: Canyon Express Project

Client: TotalFina Elf in partnership with BP and Marathon Oil

Location: Aconcagua, King's Peak, and Camden Hills Fields, Gulf of Mexico

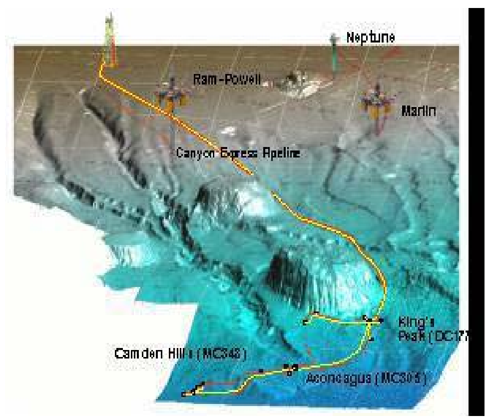
Scope: FEED and Project Execution for the complete subsea development, Preparation and evaluation of ITB packages for all subsea equipment and installation, etc.

Timeframe: December 1999 - December 2001

Project Value: USD 9 million

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



The Canyon Express Project is a first-of-a-kind industry initiative to jointly develop three area gas fields in the Gulf of Mexico, operated by different companies through a common production gathering system. The three separate fields include Aconcagua in Mississippi Canyon 305 operated by TotalFina Elf, King's Peak in Desoto Canyon 177 and 133, and Mississippi Canyon 173 and 217 operated by BP, and Camden Hills in Mississippi Canyon 348 operated by Marathon. Peak gas production from the three fields will be approximately 500 MMSCFD. A gathering system consisting of dual 12-inch pipelines will transport the gas from the three fields approximately 55 miles to Williams Canyon Station Platform located in Main Pass 261. The deepest portion of the Canyon Express pipeline system is in the Camden Hills area where the water depth is approximately 7,250 ft. Water depth at the Canyon Station Platform is 299 ft.

The Canyon Express Pipeline System must be able to produce the three fields under different operating regimes and varying production rates from multiple zone completions without any field taking on the performance risk of another field. Accurate flow allocation is therefore essential, which resulted in the use of subsea multi-phase flow meters on each of the subsea wells. Multiple well manifolds and infield flowlines have been eliminated through the use of inline well tie-in sleds installed as part of the flowlines. These inline tie-in sleds have been designed to accommodate individual subsea wells. As a result, flowline routing is dictated in large part by the location of the subsea wells. Wells are connected to the flowline tie-in sleds using conventional inverted 'U' shaped jumpers.

SCOPE OF SERVICES:

- FEED for the complete subsea development including:
  - Flow Assurance and System Engineering and Subsea Equipment Specifications
  - Flowline Design and Routing
  - Steel Catenary Risers at the Virgo Platform
  - Subsea Well Tie-in Jumpers
  - Subsea Control System, Umbilicals, and Multi-Phase Flow Meters
  - Intervention/Workover Control System
- Project execution support through installation of start-up
- Preparation and evaluation of ITB packages for all subsea equipment and installation
- Review of design and installation engineering
- QC services and management of offshore surveys
- Equipment qualification
- Procurement, expediting, SIT/EFAT, construction management, operator training and rig modification support
- O&M, IMR and intervention manuals
- Post installation start-up and operations support
- O&M, IMR and Intervention Manuals

INTECSEA
WorleyParsons Group

Project Profile

Project:	Benchamas Field Development - Subsea Tie backs
Client:	Chevron
Location:	Gulf of Thailand, Thailand
Scope:	DD/E - Detailed Design and Engineering
Timeframe:	2003
Project Value:	

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate

Concept selection studies (CPDEP Phase 2) determined that further development of the Benchamas field would be most cost-effectively achieved by subsea tieback from new minimum facilities platforms to the main Benchamas platforms and associated modifications to this main platform.

A number of networked pipelines were required which had to take into consideration future expansion and development of not only the Benchamas Field but also adjacent developments.

The project also involved significant modifications to the topsides of the main Benchamas processing platform.

WorleyParsons executed the EPCM contract for stages 1, 2 and 2B of the Benchamas Field Development.

SCOPE OF SERVICES:

The scope of work included all topsides modifications and infield flowlines and subsea wyes. The overall subsea scope covered detail design, procurement, installation and commissioning of:

- 36 km 8-inch infield pipelines and risers, 70 m water depth, 1,400 psi DP, 2* subsea wyes
- 34 km 10-inch, 8-inch and 6-inch infield pipelines and risers, 70 m water depth, 1,400/3,300 psi DP, 2* subsea wyes
- 38 km 12”, 10-inch, 8-inch and 6-inch infield pipelines and risers, 70 m water depth, 1,400/3,300 psi DP

INTECSEA
WorleyParsons Group

Project Profile

Project: Anadarko Green Canyon 518 Subsea Development

Client: Anadarko

Location: Green Canyon Block 518, Gulf of Mexico

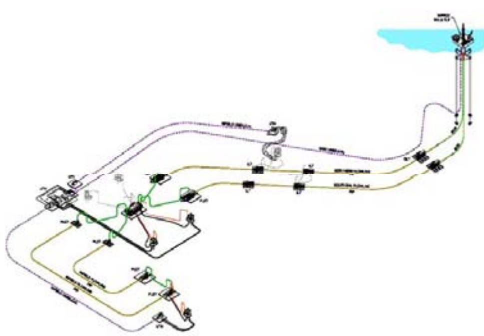
Scope: Flowline Engineering and Fabrication Support, Flowline Equipment Preliminary Detailed Design and Specifications, etc.

Timeframe: 2003

Project Value:

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



The Green Canyon Block 518 (GC 518) is located 118 miles (190 km) south of Fourchon, Louisiana in the Gulf of Mexico. The field development is in 4,000 ft to 4,285 ft (1,217 m to 1,306 m) water depth. GC 518 has a deep, high pressure, oil reservoir. All subsea equipment, flowlines, and other equipment are being designed for 10,000 psi.

Three existing wells will be connected to a single production manifold, two through insulated jumpers, and one through a pipe-in-pipe in-field flowline. The product is carried through two 12-inch x 7-inch nominal diameter pipe-in-pipe flowlines from the manifold to the Marco Polo TLP, located 8 miles away. The dual flowline architecture allows round-trip pigging. A multiplex electro-hydraulic system will be used to control and monitor the subsea facilities. The controls umbilical contains super duplex stainless steel tubes and electrical quad cables.

INTECSEA performed the complex design work under a very demanding schedule while meeting the following challenges:

- Simultaneous design and procurement activities
- First pipe-in-pipe to be made up on the firing line
- First installation of very large in-line sleds using S-lay

SCOPE OF SERVICES:

- Flowline engineering and fabrication support
- Flowline equipment preliminary design and specifications, including: PLETs, In-line sleds, well and flowline jumper
- SCR engineering and fabrication support
- Subsea production equipment engineering and fabrication support
- Subsea control system engineering and fabrication support
- Control umbilical preliminary design and specification
- Materials and welding engineering and fabrication support
- Survey assistance
- Project scheduling for the subsea facilities
- Procurement support / bid preparation and evaluation
- Preparation of pipeline right-of-way permit
- Preparation of deepwater operations plans

INTECSEA
WorleyParsons Group

Project Profile

Project: BP Alaska Northstar Pipeline Project

Client: BP Exploration, Alaska

Location: BPXA Northstar Oil Field, Alaska

Scope: Concept selection, procurement design, permitting support, specifications, procurement assistance, inspection services, offshore and onsite construction support and start-up support.

Timeframe: June 1996 - November 2001

Project Value: USD 1.08 million

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate

The BPXA Northstar Oil Field is located in 37 ft water depth, six miles offshore the Alaskan Beaufort Sea coast. It was developed by expanding the exploratory gravel island to accommodate wells, production facilities and living quarters. Produced oil is exported through a 10-inch pipeline to the Trans Alaska Pipeline System. A 10-inch gas pipeline also connects Northstar to existing Prudhoe Bay facilities. This is the world's first offshore arctic project to transport oil through a trenched subsea pipeline. The pipeline design utilized limit state strain criteria to meet the challenges of an arctic environment and marginal field economics.

INTECSEA and eight other engineering companies and construction contractors participated in an Alliance Agreement with BP. This agreement incorporated bonus/penalty incentives based on a target price and a fast-track schedule. The gas pipeline was placed in initial service supplying fuel gas to the island during 2000 and oil production started in November 2001.

SCOPE OF SERVICES:

- Specifications, procurement assistance and inspection services for engineered materials
- Welding and NDT specifications development and procedures qualification support
- Offshore construction procedure technical requirement definition and development support
- Onsite construction engineering support
- Regulatory agency and non-governmental organization interface support
- Preparation of operations, maintenance, and repair procedures
- Preparation of commissioning and start-up procedures
- As-built drawings and documentation preparation
- Evaluation of buried pipeline vertical movements and wax control during pipeline warm-up period

Project Profile

Project: ADMA OPCP - Umm Shaif Pipeline and Cable Project

Client: Hyundai Heavy Industries Co., Ltd (HHI)

Location: Abu Dhabi sector of the Arabian Gulf

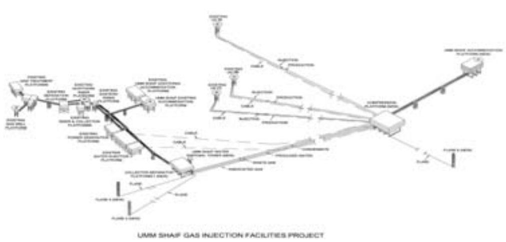
Scope: USGIF process lines, Crestal WHT gas production and injection pipelines; piggyback pipelines, and subsea power cables comprising of the USSC-USGIF power cables.

Timeframe: January 2007 - Ongoing

Project Value:

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



The Umm Shaif is located in the Abu Dhabi sector of the Arabian Gulf. The Umm Shaif Gas Injection Facilities (USGIF) project represents the first phase of a major re-development of the Umm Shaif Field.

As part of this USGIF Phase I Development, new facilities will be designed to handle the predicted increase in Umm Shaif Oil Reservoir GOR and water cut up to year 2020. The new oil separation facilities will be located on a third platform, Collector Separator Platform, CSP-1, bridge connected to USSC and will process well stream fluids transferred from the existing USSC and from a future riser platform (not part of this scope). The facilities will be designed to handle 305,000 stbpd oil for export to Das Island, 1000 MMSCFD of associated gas for export (max. 900 MMSCFD) or re-injection and teat 125,000 bpd produced water for disposal into an offshore aquifer via a new Water Disposal Tower UWDT bridge connected to CSP-1.

SCOPE OF SERVICES:

- High Pressure High Temperature Pipelines
- Extremely high H2S concentrations

INTECSEA
WorleyParsons Group

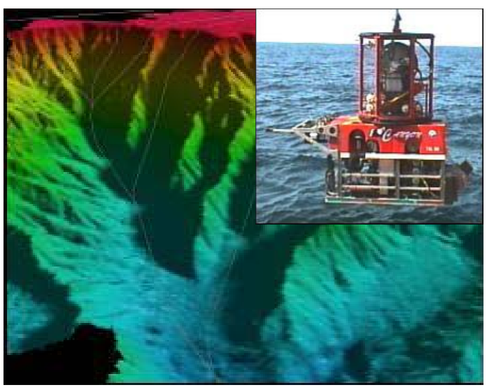
Project Profile

Project: Gazprom Blue Stream Pipeline Project
Client: Gazprom and PeterGaz B.V., a wholly owned subsidiary of Gazprom
Location: Black Sea
Scope: Feasibility Study and FEED

Timeframe: January 1999 - November 2002
Project Value:

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



The Blue Stream Pipeline Project is a gas transportation system for delivery of processed gas from the gas grid in Southern Russia, across the Black Sea to Ankara, Turkey. The Blue Stream Project includes two 24-inch offshore pipelines, which traverse a route from Djubga, Russia to a landfall east of Samsun, Turkey. The pipelines are approximately 390 kilometers long and were installed in water depths to 2,150 meters.

SCOPE OF SERVICES:

INTECSEA was responsible for the feasibility study and the detailed engineering of the pipeline system. This included:

- Route selection, bathymetric, geophysical, geotechnical and seismic surveys
- Geo-hazard, on-slope stability and pipeline integrity assessments
- Bottom roughness and span assessments
- Materials testing including lab and field crack susceptibility, anode and coating tests, for the sour environment of the Black Sea
- Cathodic protection and coating design
- Line pipe specification
- Full-scale collapse testing including buckle propagation and the effects of thermal aging
- Probabilistic and deterministic wall thickness and buckle arrestor designs
- Hydraulic analysis and hydrate mitigation
- Risk analysis for design, construction and operational phases of the project
- Operations and maintenance studies

Gas delivery via the Blue Stream started late 2002.

INTECSEA
WorleyParsons Group

Project Profile

Project: Exxon Mobile Bay CRA Flowline Project

Client: Exxon Company, USA

Location: Mobile Bay, Alabama

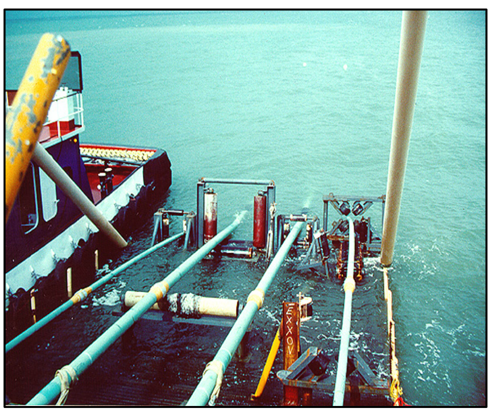
Scope: Carrier Line Pipe Material Studies and CRA Weld Development and Patent Application, etc.

Timeframe: November 1989 - December 1992; January 1997 - December 1997

Project Value:

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate



The project included detailed design, relevant component testing and installation supervision of several high temperature, high pressure insulated sour gas flowlines for Exxon developments in Mobile Bay, Alabama. A number of innovative techniques were applied to reduce cost, improve safety and ensure long term protection of the environment. The design entailed the first use of ultra high strength corrosion resistant materials for carrier pipe applications. Hastelloy Grade 110 (Nickel, Iron, Chrome, Molybdenum) was used for resistance to H2S and hoop strength. This required the development of a welding procedure that could be used with cold worked material. A patent was developed after successful testing and application. Inconel (Grade 625) risers were used for temperatures to 300º F and pressures to 11,000 psig. The 4-inch carrier pipe was contained in an 8-inch carbon steel jacket pipe. Polyurethane foam with a mineral wool buffer was used to meet thermal requirements. The flowlines were installed using a dedicated laybarge specifically developed for work in shallow water. Two barges were linked end to end to increase the number of weld stations for pipe-in-pipe make-up. The crossing of the Mobile Bay Ship Channel required directional drilling using an innovative wetto- wet arrangement to avoid damaging the sensitive environment.

SCOPE OF SERVICES:

- Carrier line pipe material studies and CRA weld development and patent application
- Insulated pipe-in-pipe detailed design and bulkhead FEM analysis and design
- Structural analysis and field joint design and upheaval buckling and burial analyses
- Flowline design and fabrication procedures
- Riser design (insulated) for cold-spring application
- Thermal, pressure and structural test programs
- Power cable with fiber optic signal design and installation procedures
- Directionally drilled ship channel crossing procedures and specifications
- Flowline route selection and alignment sheets
- Material and fabrication specifications
- Installation strategy development and fabrication procedure support
- Fabrication inspection and supervision and offshore construction supervision
- Safety and HAZOP analysis

The work was performed from 1989 to 1992. In 1997, Exxon made additions to the field with INTECSEA providing similar services.

Project Profile

Project: Towngas - Pipeline Integrity Study

Client: The Hong Kong and China Gas Company Ltd (Towngas)

Location: Hong Kong

Scope: Corrosion prediction and assessment

Timeframe: May - July 2007

Project Value:

Phases:

1	2	3	4	5
Identify	Select	Define	Execute	Operate

The existing Ma Tau Kok (MTK) – North Point (NP) submarine pipelines in Hong Kong have commenced operation since 1978. Initially after commissioning till 1990 the pipelines were operated wet gas and subsequently in dry mode.

A recent corrosion inspection found an area of metal loss with a peak depth at 23% wall thickness at the East Pipeline about some 300 m from MTK.

In order to assess the integrity of the pipeline, WorleyParsons proposed a four-step methodology including:

1) code-based integrity assessment based on the measured corrosion data;
2) FEA-based integrity assessment using ABAQUS;
3) Theoretical prediction of internal corrosion and evaluation of external corrosion protection;
4) Second round integrity assessment using the predicted corrosion data up to the year of 2015. Based on the solid assessment, it is concluded that the pipeline can operate in safe mode up to 2015 since the calculated safe working pressure is larger than the current operating pressure.

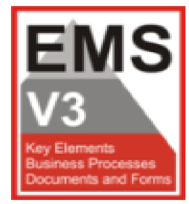
SCOPE OF SERVICES:

- Integrity assessment of Towngas pipeline using DNV codes and Finite Element Method
- Theoretical prediction of internal corrosion and evaluation of external protection.

Project Management

WorleyParsons maintains a comprehensive suite of tools to manage projects at the highest level around the world. WorleyParsons employs a consistent, proven suite of group-wide processes, systems and tools supported by functional managers (Business Process Owners, or BPOs) and Business Systems Groups (developers, trainers, start-up support, help desk, commercial agreements, etc) scalable for any size project.

Enterprise Management System (EMS) web enabled repository of policies, directives, standard workflows, procedures, guidelines, forms, and checklists content controlled by BPOs EMS is easily accessible in any of our offices and is company standard enabling the more than 30,000 staff in 110 offices to share work on a common platform. The supporting systems are tailored to apply in each of the following stages of a project: Identify, Select, Define, Execute, and Operate.



WorleyParsons Project Management Process (WPMP) is our scalable, risk based framework for project execution – some content mandatory, most is advisory.

The main principles of WorleyParsons Management Processes are:

- It is s a matrix of mandatory or potential tasks applicable for each project phase. Mandatory tasks kept to a minimum
- Project Value Objectives are clearly documented, and Maximum Value identified and realized
- Decision support package requirements are fundamental to what is planned for and delivered in each phase
- Value Improving Practices (VIPs) are used as appropriate
- Each of the tasks is summarized in an overview task sheet, supported as required by:
  - Procedures
  - Corporate Guidelines
  - Template Project Plans
  - Go-Bys

The system includes prompts and go-bys easily available for each phase of the work, illustrated by the following examples for Select Phase projects:

Phase 2 SELECT

Task	E1	E2	E3	E4	P1	P2	P3	P4
Activity : 2.0 Organisation (ORG) (7)								
ORG001 Project Execution Plan (PEP)	M	M	M	M				
ORG002 Communications Plan				✓				
ORG005 Align Project Objectives/Strategies (KSF's)				✓				
ORG006 Interface Management Plan				✓				
ORG007 Stakeholder Management Plan				✓				
ORG009 Virtual Teaming Plan	✓	✓	✓	✓				
ORG010 Project Closeout Plan	✓	✓	✓	✓				
Activity : 3.0 Project Control (PC) (15)								
PC001 Work Breakdown Structure (WBS)	✓	✓	✓	✓				
PC002 Capital Cost Estimate Plan		✓	M	M				
PC004 Cost Estimate - Class 2	✓	✓	✓	✓				
PC007 Project Controls Plan				✓				
PC008 Staffhour Estimates	✓	✓	✓	✓				
PC009 Project Scheduling			✓	✓				
PC010 Management of Change (MoC)	M	M	M	M				
PC011 Cost Risk Analysis			✓	✓				
PC013 Project Prioritisation	✓	✓	✓	✓				
PC014 Project Cost Control	✓	✓	✓	✓				
PC015 Progress Measurement & Reporting	✓	✓	✓	✓				
PC016 IT Infrastructure / Systems Plan				✓				
PC017 Document & Data Management Plan				✓				
PC018 Project Reporting Plan	✓	✓	✓	✓				
PC019 Senior Management Review of Project Status		M	M	M				
Activity : 4.0 Assurance & Risk (AR) (8)								
AR001 Project Risk Classification	M	M	M	M				

Guide to using the Filter by Project Category

Select the combination of project services type:

- Engineering Only or
- Engineering & Procurement , EPCM or EPC

together with the project risk classification based on PMF-053 , namely:

A+, A, B or C

Filter by Project Category

- E1=Engineering Only (C)
- E2=Engineering Only (B)
- E3=Engineering Only (A)
- E4=Engineering Only (A+)
- P1=EP/EPCM/EPC (C)
- P2=EP/EPCM/EPC (B)
- P3=EP/EPCM/EPC (A)
- P4=EP/EPCM/EPC (A+)

Phases:

Phase 1 IDENTIFY

Phase 3 DEFINE

Phase 4 EXECUTE

Phase 5 OPERATE

KEY

M Mandatory Requirement

✓ Recommended for Consideration

INTECSEA
WorleyParsons Group

InControl is our CTR based project cost and resources control tool - for small or large projects. It is WorleyParsons proprietary, but interfaces with third party applications plus selected third party applications under global agreements – Intergraph (PDS, Marian and SmartPlant Foundation), Primavera, Oracle, Quest, etc.

Other supporting systems include:

- Primavera Project P3
  - Project planning and control
- Cost Management System (CMS)
  - Estimating cost and schedule impact due to project changes
- Scorecard
  - Engineering progress measurement and productivity
- Project Portal (EDMS)
  - Secure, web-based, integrates closely with Microsoft Office 2003
  - Data, schedules, and documents can be accessed from a central location by project teams, clients and vendors worldwide
- Encompass®
  - Total project management information tool
  - Up-to-date and accurate information not only in the home office, but at the job site and at select partner or customers sites as well
  - Information can be shared worldwide by project teams

Interface Management is one of the most critical management practices that must be performed to an excellence-in-execution result. Interface Management is core-defined as eliminating "the gaps and the overlaps." In principle, Interface Management is clearly recognized by INTECSEA as a key active component of our Project Execution Plan.

The key is to recognize what information is required at what time by whom and where and to handle the constant flow of information, decisions, and requirements between all the stakeholders in the project. To this effect a common interface management process needs to be established among all parties; this requires that the interface management process is clearly identified as a contractual obligation between all parties.

There are multiple levels of information exchange:

Internal:

- Between individual disciplines within Client team
- Between Client team and contractors,

External:

- Between the internal groups within the contractor
- Between vendors, subcontractors, and 3rd parties and the main Contractor

Based on the experiences gained by INTECSEA, a methodology has been developed that suits most projects and applies to both internal and external interface management. The purpose of the IMS will be to maintain lines of communication between different stakeholders and Contractor(s) and, ensuring that technical details are consistent, schedule delivery dates are achieved and costs are kept within an agreed budget, as well as providing early warning to interfacing conflicts and tracking the effects of change.

The objectives of our Interface Management process are to:

- Define the Information Exchange Requirements throughout all Phases of a Project
  - General Project Information
  - Equipment Interfaces
- Information Required by Who and When
  - Project Schedule and Milestones
  - Deliverables
  - Contractor Workscopes
- Monitor the Exchange of Information
  - Take Corrective Action through an Early Warning System

Excellent communication is of course an essential ingredient, but it needs to be accomplished in a systematic way to ensure interfaces are handled most effectively. Typically managing, coordinating and resolving interfaces are the role of an Interface Manager who reports directly to the Project Manager. His role is to systematically track the information exchange and its impact on progress.

INTECSEA's Interface Management Process is a proven system tool to support the tracking, management, and effectiveness of the exchange of important project information.

Our IM system provides the following reports:

- General Interface Information Reporting (general interface physical properties)
- Interface Schedule Information Reporting (inter-related activities associated with search)
- Interface Clarification Register (listing issues, date raised, due date, resolution)
- Change Report (documenting the changes and the responsible parties)
- Document and Drawing Register (listing project and 'shadow' document status)

INTECSEA personnel have been responsible for interfaces on a number of recent projects, such as the ChevronTexaco Agbami project. This major undertaking requires the management of over 85,000 interfaces between disciplines and contracts. The system was established during the FEED phase to coordinate the design effort and will continue throughout project execution phase to support management of the vendors and contractors.

The INTECSEA Interface Management System (IMS)

General interface information is organized on three working levels with increasing detail. It reports general interface physical properties for attributes, components and tasks. The system links with the project scheduling tools to identify impacts and monitor status. The Interface Clarification Register lists issues, dates raised and due, resolution, responsible party and resolution team. The change report documents changes to interfaces, tasks and milestones. The Document and Drawing Register lists current document and "shadow" document status.

A graphical interface, an example of which is shown in Figure 1 below, enables ease in finding related interfaces and facilitates coordination among the project participants.

INTECSEA IMS Concept Presentation

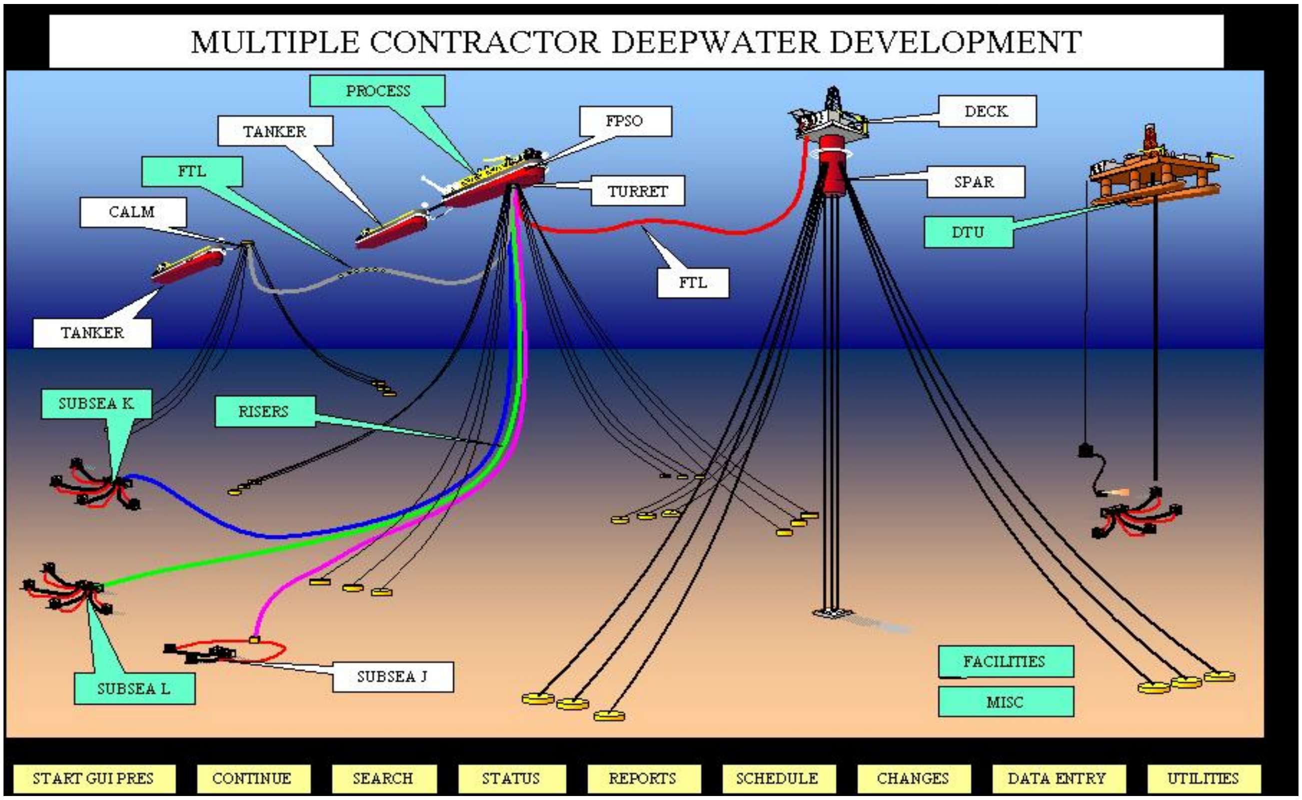


Figure 1: Graphical Interface on Typical Multi-Faceted Development

Effective interface management is key to the successful delivery of FEED and Detailed design. An Interface Management System (IMS) will be established during the FEED phase to identify and define design and disciplines interfaces and then continue through project execution to coordinate multiple contracts and suppliers.

The purpose of the IMS will be to maintain lines of communication between different disciplines, groups, companies, and contractors to ensure that technical details are consistent, schedule delivery dates are achieved, and costs are kept within an agreed budget, as well as providing early warning to interface issues and a mechanism for resolving.

Interfaces are either internal (within a defined component, assembly, or work scope) or external (between components, assemblies, work scopes, or organizations). As the project advances into the FEED, detail design, and execution phases, the management of external interfaces becomes more important and complex.

INTECSEA has developed an Interface Management System (IMS) methodology consisting of procedures, work processes and computer tools. The model is applicable to both internal and external project interfaces and can be adapted to suit any size or type of single or multi-faceted project. The Interface Management System (IMS) was developed by INTECSEA and incorporates the necessary procedures, work processes and computer tools to aid in the management of project interfaces. INTECSEA is currently providing complete interface management of ChevronTexaco's Agbami project, a major project including an FPSO, subsea, flowlines and offloading. Initially, the system was applied to the substantial engineering tasks and will continue into management of the multiple EPC contract elements of the project.

The Interface Management Tool (IM Tool) is a robust database application accessible worldwide though the intranet. It stores and manages project interface information as well as interface links and key dates. Parties receive notifications of interface queries and actions by email, and can use the web interface to respond.

INTECSEA will offer Client the Interface Management System (IMS) modified to suit the particular needs of the project, including both internal and external interface management, and with suitably experienced engineers. The full IMS package will ensure that interface issues are identified and discussed between all affected parties.

The IMS will control the following aspect of the project:

- Contractual responsibilities and requirements
- Engineering tasks and activities
- Design reports issue and revision dates
- Interface physical properties
- Project milestones

- Procurement
- Construction
- Installation and commissioning
- Operation and Maintenance

Interface Management Process

The Interface Management Process ensures effective management of functional, physical, schedule and cost interfaces within the project. The Interface Management System will be the basis for all parties to communicate on interface issues to ensure that interface issues are identified and discussed between all affected parties and to develop agreed mechanisms, responsibilities, and completion dates for resolution of issues.

The Interface Management Process for the project will be periodically updated to account for revisions to the working process accounting for CLIENT requirements. Figure 2 below, shows the key elements in the IMS Work Process.

INTECSEA IMS Work Process

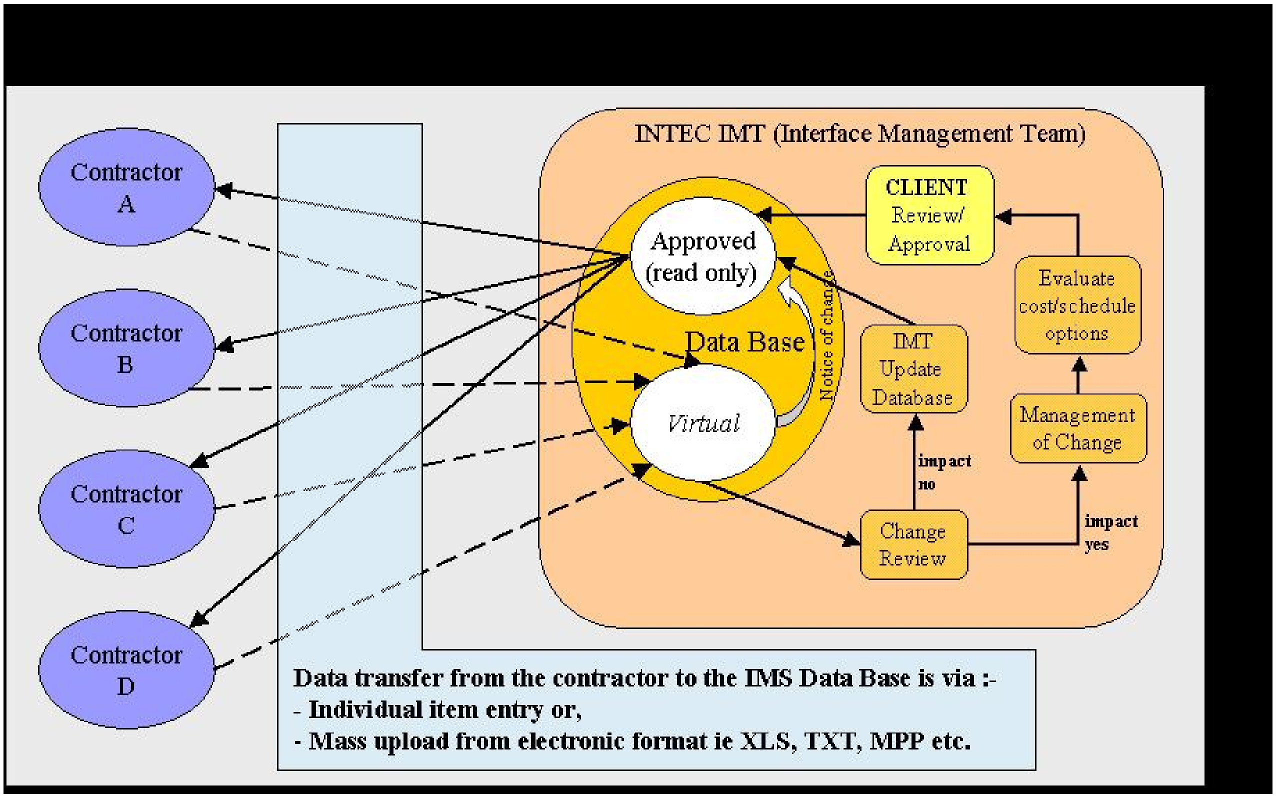


Figure 2: IMS Work Process Flow

Integration management will be a key element in ensuring the successful outcome of the project and will avoid costly delays during fabrication, hook-up, installation and commissioning activities.

The Interface Manager will be responsible for the following:

- Chair regularly scheduled project-wide Interface Meetings. Chair and/or attend other meetings as required and appropriate.
- Ensure that technical interfaces (both functional and physical) and contractual interfaces (cost and schedule) within its own scope of supply and between itself and other relevant parties are identified, recorded, understood, agreed upon by all parties, and reported to the IMS.
- Review Client and Contractor interface documentation to ensure that appropriate responsible parties have been informed of and have been provided input to interface issues and that issues have been properly identified, resolved, and documented.
- Review all Change Requests and significant non-conformance reports and dispositions to assure that interface issues are appropriately identified and resolved.
- Maintain an Interface Register and Interface Database.
- Identify and report progress, concerns and actions to resolve problems and any impact to other areas of the development.
- Manage the resolution and timely closeout of relevant interface issues.
- Provide relevant information or data to those groups within the Client, own organization and other contracting parties, which may have need of, or be impacted by, the subject information.
- Coordinate review and approval for all procedures, data, instructions, drawings, etc. at relevant work interfaces.
- Coordinate review and approval of Change Requests to ensure that interface issues are recognized and addressed.
- Coordinate review and approval of all significant non-conformance reports and dispositions to ensure that interface issues are recognized and addressed.
- Communicate (via appropriate documentation) issues and resolutions to all affected parties.
- Inform the Client and INTECSEA IMS Team of all inter-organization interface meetings at the time they are organized. Client and INTECSEA may attend these meetings as necessary or appropriate.

Each of the managed (EPC) contractors will be made responsible for implementing an interface management system within its own organization and shall participate in operation of the PMT Interface Management System. Each managed contractor will appoint an Interface Coordinator who will coordinate issue resolution activities within their organization and will communicate these resolutions to the PMT Interface Manager. The Interface Coordinator shall be a single-point-of-contact on the managed contractor's interface issues. Each contractor shall establish within its own organization an interface management system to:

- Ensure that technical interfaces (both functional and physical) and contractual interfaces (cost and schedule) within its own scope of supply and between itself and other relevant parties are identified, recorded, understood, agreed upon by all parties, and reported to the IMS.
- Manage the resolution and timely closeout of relevant interface issues.
- Provide relevant information or data to those groups within the contractor's own organization, which may have need of, or be impacted by, the subject information.
- Provide relevant information or data to other contracting parties and to the IMS, which may have need of, or be impacted by, the subject information.
- Coordinate review and approval for all procedures, data, instructions, drawings, etc. at relevant work interfaces.
- Coordinate review and approval of Change Requests to ensure that interface issues are recognized and addressed.
- Coordinate review and approval of all significant non-conformance reports and dispositions to ensure that interface issues are recognized and addressed.

Reporting

Following resolution of an interface issue, the resolving party will provide appropriate documents, including Change Request and significant non-conformance review and actions, to the affected parties and to the Interface Manager for the record. The Interface Manager will record all agreements and actions in a suitable form and other appropriate documentation, as required. Systems Interface information shown in the form(s) will also be tracked in a database to provide ready access to the data developed. A sample of typical IMS report is shown below.

Interface Name — **FTL-04 Production FTL Connection at SPAR**

INTECSEA WorleyParsons Group

System:	Water Injection	**Interface No.** FTL 153-01	**Data Sheet No.** FTL-153-01-01
Interface Description	FTL Attachment to the DTU		
Interface Location		**Revision** A / **Initials** NH / **Rev. Date** 19/03/02	
Interfacing Parties	FPSO	FPSO engineering contractor	
	SUB-SEA	Sub-Sea engineerig & installation contractor	
	SPAR	SPAR engineering contractor	
	FAC	Client Facility management	

General Interface Information									Interface Specific Document		
No.	**Description**	**Value**	**UOM**	**Responsible**	**STATUS** R	A	G	B	**Document No.**	**Rev.**	**Document No.**
1	Nominal Dia	6.6"	inch	SUB_SEA			G		AGB-C-00-009		Subsea Installation Scope of Work (Volume 4)
2	Design Flow Rate	80	kbwd	FAC				B	DSG-RI-3890		*Riser Loads for FPSO Mooring System Design*
3	Length (Approx)	586	m	FAC			G		AGB-C-00-009		Subsea Installation Scope of Work (Volume 4)
4	Weight/meter Length	tba	kg/m	SUB_SEA		A					
5	Minimum Bend Radius	tba	m	SUB_SEA		A					
6	Design Pressure	5000	psi	FAC			G		AGB-C-00-009		Subsea Installation Scope of Work (Volume 4)
7	Maximum Operating Tension	40	Te	SUB_SEA			G		DSG-RI-3890		*Riser Loads for FPSO Mooring System Design*
8	Maximum Operating Side Load	27	Te	SUB_SEA			G		DSG-RI-3891		*Riser Loads for FPSO Mooring System Design*
9	Vertical Approach Angle for Max Op Ten'n	43	deg	SPAR			G		DSG-RI-3892		*Riser Loads for FPSO Mooring System Design*
10	Pull-In Load	tba		SUB_SEA	R	A					
11											
12											
13											

General Notes:

The general information included on this form is for interface imanagement only and is given in good faith.
For engineering purposes the reader must refer to the appropriate drawings and specifications for details.

IMS Tool

The INTECSEA IMS is a Web based application, accessible from all project locations through the Internet. The interface database resides on INTECSEA's server in Houston, where the program is maintained periodically updated when new features become available. The application will provide:

- WEB based Interface Management System for remote job site access and secure access from anywhere in the world:
- Unbiased procedures to formally assess, resolve and document interface issues and conflicts;
- IMS Team defined Fabricator(s), Contractor(s) and Sub-contractor(s) access rights;
- A high level Graphic User Interface (GUI) for quick location of project interfaces;
- Early warning of interface clashes, reduced schedule float, and notification of change;
- Reporting of schedule and cost issues;
- "Traffic Light" status to clearly present interface, management and contract issues;
- General data, e.g. interface liaison personnel details, interface matrices etc.;
- Single item data entry by each user to a "Virtual Database";
- Mass data file upload via IMS tools using industry standard application files (e.g. Excel, Primavera, MS Project, etc.); and
- Adaptable search tools for database Interrogation and Reporting.