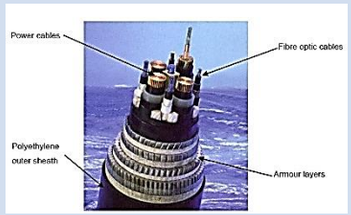
Deepwater Reference Book – Umbilicals - Synopsis

Umbilical Cross Section & Function/Properties

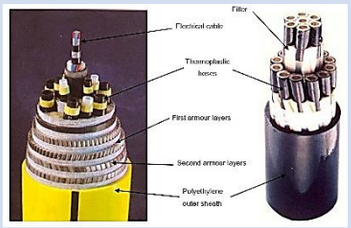
An umbilical is a bundle of tubes and cables that:

- **provides hydraulic power to subsea control systems**
- **provides electric power and signal to subsea control systems**
- **delivers chemicals for subsea injection at the subsea equipment or downhole**
- **can provide bulk methanol**
- **can provide gas for gas lift**

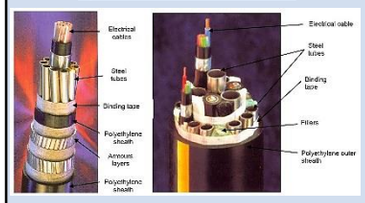
Dynamic Power & Control Umbilical



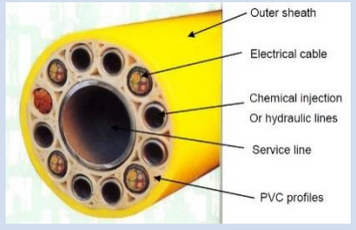
Dynamic electro-hydraulic (left) & Static hydraulic (right) thermoplastic umbilical



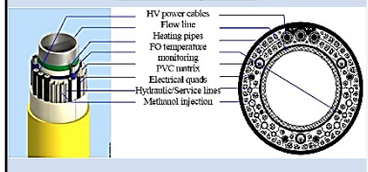
Dynamic (left) & Static (right) electro-hydraulic steel tube umbilical



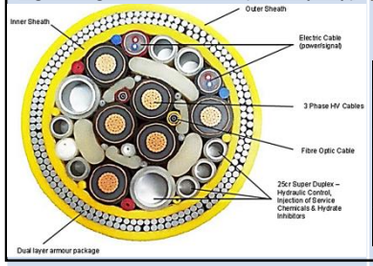
Integrated service umbilical



Integrated Production Umbilical (Static or dynamic)



High Voltage Power Umbilical (Subsea pump)



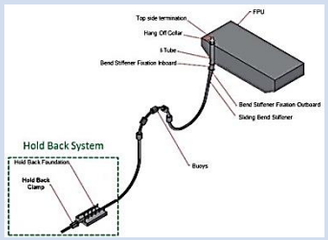
Umbilical configurations & properties (Static & Dynamic)

Static Umbilical

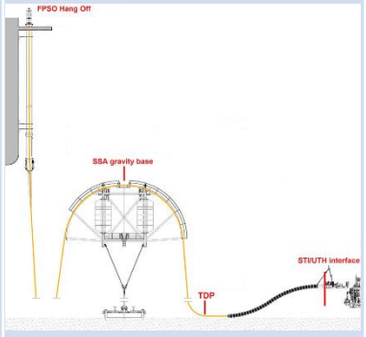
Dynamic Umbilical

Dynamic Umbilical – Free hanging inside pre-installed I-tube

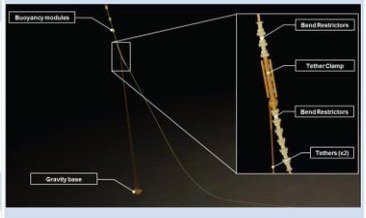
Dynamic Umbilical S-lazy wave with buoyancy modules



Dynamic Umbilical S-lazy wave with mid-water arch



Dynamic Umbilical reverse pliant wave configuration

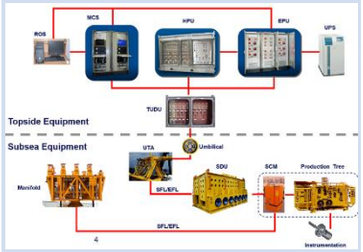


Umbilical properties

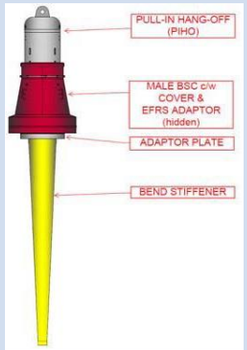
Project	Umbilical type	OD [mm]	Weight in air (empty) [Kg/m]	MBR storage [m]	Supplier
Moho Nord	Production static or dynamic umbilical	174	34,3	2,59	TechnipFMC
	Water injection static umbilical	108	14,8	1,62	TechnipFMC
	SSIV dynamic umbilical	117	27,3	1,35	TechnipFMC
Moho Phase 1Bis	MPP Umbilical	230,5	90,1	2,5	OneSubsea
	Gas Lift Umbilical	264	110,4	3,3	TechnipFMC
Egina	Production dynamic umbilical	194,5	45,9	2,91	TechnipFMC
	Production static umbilical	182,1	42,2	2,73	TechnipFMC
	Water Injection static umbilical	94,3	11,5	1,41	TechnipFMC
	SIV/Riser Monitoring dynamic umbilical	165	40,8	2,04	TechnipFMC
	Riser Monitoring static umbilical	82,5	12,6	0,79	TechnipFMC
Kaombo	Production dynamic umbilical	201,7	46,1	9,9	TechnipFMC
	Production static umbilical	193,7	39,7	10,1	TechnipFMC
	Water Injection static umbilical	84,3	8,8	4,6	TechnipFMC
	SSIV control cable	197,1	62,6	4,6	TechnipFMC

Umbilical Terminations

Umbilicals are typically terminated subsea by an umbilical termination assembly (UTA), which allows for the distribution of hydraulics, chemicals, and electrical signal and power through flying leads connecting the UTA to the subsea production system.



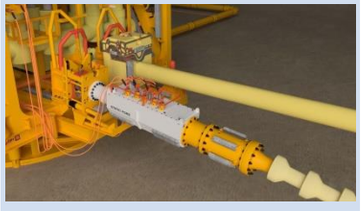
Topside Termination



Subsea Termination

A UTA or SDU distributes the hydraulic and electric power and signal from the umbilical to the various subsea control pods.
A UTA is typically attached to and installed with the umbilical, while the SDU is installed separately and connected to the umbilical UTA with a flying lead.

Umbilical Termination Head (UTH)



Cobra Head Assembly (CHA)

Subsea Distribution Unit (SDU)

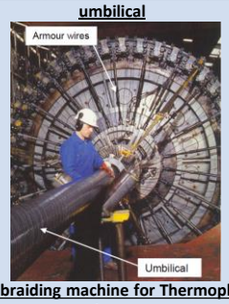
Fabrication Method

Helical lay-up machine for steel tube umbilical

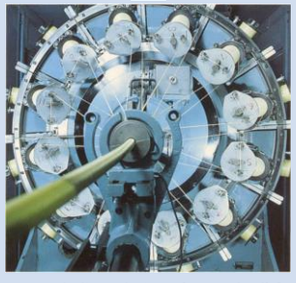
Helical lay-up machine for Integrated Service Umbilical (Aker Solutions)

Extruding machine

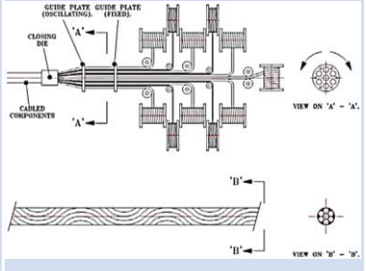
Armouring machine for Thermoplastic umbilical



Hose braiding machine for Thermoplastic hose



Reverse helix technique (SZ method) for umbilical assembly, integrated service umbilical and gas lift umbilical



Fabrication Test

Material qualification testing

	Test type	Criteria, purposes
Steel tube material	Mechanical tests (Yield, Tensile, Elongation)	Tension loads, strains
	Hardness test	Fatigue, cracks
	Butt welded tube fatigue testing	Fatigue
	Pitting corrosion test	Corrosion, life cycle
	Flattening test	Loading, crushing
	Flaring test	Fire resistant
	Ultrasonic testing	Tension loads, fatigue
	Metallographic examination for super duplex	Ferrite content, sigma phase
	Eddy current test	Fatigue, cracks
	Burst test	safety limit to tensile stress
	Proof pressure test	safaty limit to yield stress
Electric cables	DC conductor resistance	Line integrity
	Insulation resistance	Depth pressure, water-proof
	High voltage DC	Function capabilities
Data transmissions	Conventional copper wire signal	Between 1200 and 4800 bits per second and bit error of less than 1 in 10^5 bits
	Optical cables	About 55 Mbit per second and bit error rates of better than 10^-9

Umbilical design qualification testing

Fatigue tests

Tensile-torque balance test

Crush / friction and tension tests

Tensile breaking strength
Reeling and straightening capacity (as regard to installation purposes)
Tensile/torque balance test
Flex fatigue of umbilical and topside hang-off arrangement
Crush friction and resistance test
Bend stiffness test

Acceptance testing

	Test type
Steel tubes and thermoplastic hoses (full production lengths)	Visual inspection Dimensional checks Burst pressure test (samples only) Proof pressure test (1.5 x design pressure)
Electric cables	Hydrostatic testing @ 35 bar.g of insulated conductors DC conductor resistance Insulation resistance High voltage DC Time domain reflectometry
Umbilical	**Electrical cables:** - DC conductor resistance - Insulation resistance - High voltage DC - Time domain reflectometry **Hydraulic tests:** - Proof pressure tests and decay test (hoses) - Proof pressure test (steel tubes) - Flow rate test in turbulent conditions (steel tubes and hoses) - Dimensional and visual (steel tubes and hoses) - Hydraulic fluid cleanliness (steel tubes and hoses) **Check of data transmission performances**

Extent of flushing, pressure testing, cleaning & preservation

Line Type	Flushing &Cleaning	Pressure test			Pickling *	Hot oil flushing	Flow test	Cleanliness		Preservation	
	Prefab	Prefab	FAT	Load out	Prefab	FAT	FAT	FAT	Load out	FAT	Load out
Chemical / service lines	X	X	X	X				X		X	X
Hydraulic lines	X	X	X	X	X	X	X	X	X	X	X

Material key issues

Material	Key issues
Carbon steel	Corrosion
Duplex and super duplex	• Pitting • Hydrogen embrittlement of the welds
Titanium	• Stress Corrosion Cracking in methanol • Resistance to cathodic protection

Suppliers

Suppliers:

Suppliers	Fabrication location	Approved by Total
TECHNIPFMC	UK, USA, Angola	Yes
NEXANS	Norway	HOLD
AKER SOLUTIONS	Norway	Yes
OCEANEERING	HOLD	Yes
PRYSMIAN	France	HOLD
JDR CABLE SYSTEMS	UK, USA	HOLD
NKT	Europe	HOLD
ONESUBSEA	Europe	Yes

JDR cable systems is not qualified for not qualified for super duplex steel tube umbilical

Laying Vessels

Three vessel types:

- **Carousel-lay vessel**
- **Reel-lay vessel**
- **Flex-lay vessel**

Carousel-lay vessel

Isaac Newton

Characteristics:

- **Can install up to 10700 ton of cable**
- **2 turntables (7400 ton capacity above deck, 5000 ton capacity below deck)**
- **2 tensioners of 20 ton**

Reel-lay vessel

Seven Oceans

Characteristics:

- **Maximum operating depth 3000m**
- **Lay ramp equipped with 300 ton tensioner, 4501 ton and 80 ton A&R winch and 16mt knuckle-boom crane**

Flex-lay vessel with vertical lay system

Seven waves

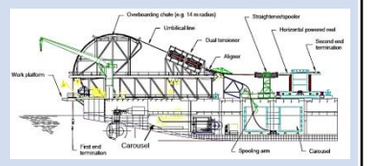
Characteristics:

- **Water depth until 2500m**
- **Umbilical diameter : 100mm to 630mm**
- **Vertical (tiltable) lay system (550t top tension capacity)**
- **twin ROVs**
- **2 underdeck storage carousels (2500 tons & 1500 tons capacity)**

Installation Procedure

Laying equipment

Umbilical can be laid directly from a storage reel or via a tensioner system and associated carousel basket installed on main deck or inside the installation vessel.

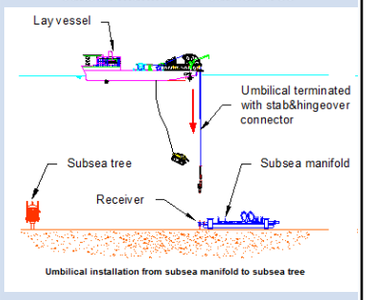


Installation criteria

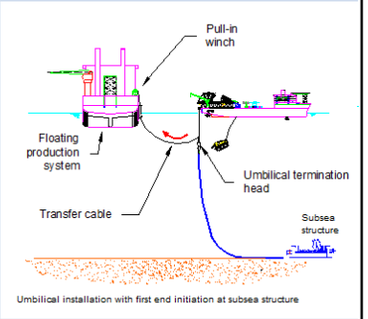
- **Maximum 2% cumulative strains**
- **Large radius overboarding chutes (e.g. 14 m) to keep the 'as laid' umbilical steel tubes within the elastic domain (or less than 1% residual strain), with typical 3°-5° departure angle**

Laying methods

Method 1: Umbilical installation from subsea manifold to subsea tree



Method 2: Umbilical installation with first end initiation at subsea structure



Method 3: Umbilical installation with first end initiation at floater