

HANDBOOK OF TERMINOLOGY FOR THE USE OF DIVERS AND INSPECTORS ON OFFSHORE STRUCTURES

*Prepared by the Operational Advisory Subcommittee on
Underwater Inspection and Diving Unit for
the Department of Energy*

DEPARTMENT OF ENERGY

OFFSHORE TECHNOLOGY REPORT

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A Handbook of Terminology for the use of Divers and Inspectors on Offshore Structures

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TABLE OF CONTENTS

	Page
FOREWARD	v
ACKNOWLEDGEMENTS	vii
1. OFFSHORE FACILITIES	
1.1 Platforms, Floating Production Units, Subsea Systems and Loading Facilities	1
1.2 Pipelines	23
2. INSPECTION	
2.1 Equipment and Techniques	37
2.2 Magnetic Particle Inspection	49
2.3 Radiography	61
2.4 Ultrasonics	73
2.5 Photography	93
2.6 Video	107
2.7 Planning and Reporting	113
2.8 Biological Fouling	127
2.9 Corrosion and Protection	133
2.10 General Defects	147
2.11 Weld Defects	151
3. MATERIALS AND WELD INSPECTION	157
4. CONCRETE	171

FOREWORD

The offshore industry has associated with its activities terms and jargon which very often can create confusion due to differing individual interpretations or lack of understanding. This handbook has been produced to solve this problem. It is intended for use by Diver Inspectors, Engineers and Technicians or anyone with an interest in the subject.

Some of the terms used can be broadly applied to other areas of industry. The definitions given here however, apply to their use in the context of the offshore oil and gas industry.

The document is designed for reference purposes and should not be regarded as definitive work on any of the topics covered.

ACKNOWLEDGEMENTS

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1. OFFSHORE FACILITIES

1.1 PLATFORMS, FLOATING PRODUCTION UNITS, SUBSEA SYSTEMS AND LOADING FACILITIES

<u>Term</u>	<u>Definition</u>
	A
ACCOMMODATION MODULE	A part of a production platform, separate from the drilling and production areas where the personnel live. May be on a separate platform connected by a bridge to the production platform.
ALP	Articulated Loading Platform. A type of Single Point Mooring (SPM) consisting of a lattice structure connected to a mooring base by an articulated joint. See figure 1 overleaf.
ANCHOR	Any device by means of which equipment or vessel may be secured or fastened.
ANCHORED STRUCTURE	A floating production platform held in place by a low tension chain mooring system. Often a converted semi-submersible.
ANDOC STRUCTURE (ANGLO-DUTCH OFFSHORE CONCRETE)	A concrete gravity platform with a square cellular caisson and four columns (30m steel on 112m concrete) supporting the deck. The caisson has steel skirts below. Similar to Seatank. Dunlin A is the one example built to date.

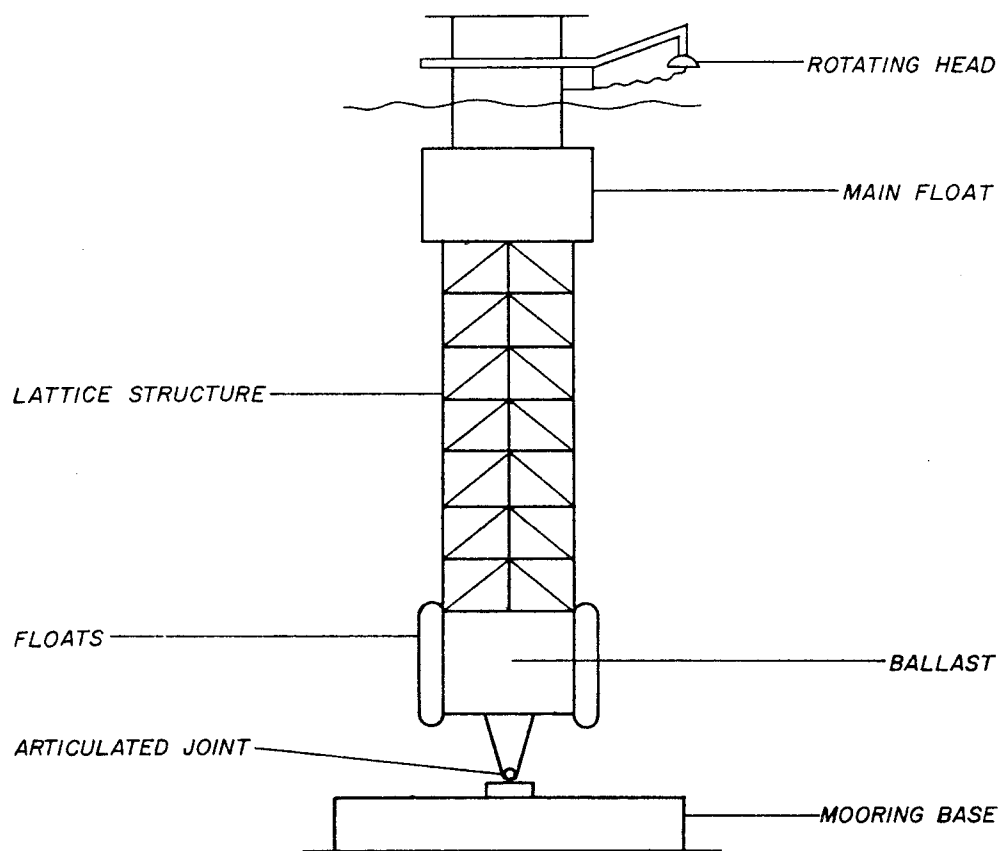


Figure 1: Example of Articulated Loading Platform (ALP)

ANODE

In general an electrically active component or area which loses electrons and, therefore, corrodes. On a jacket "anode" either refers to the sacrificial anodes (e.g. zinc) installed to protect the steel structure by supplying electrons to the steel, or to "impressed current anodes" which perform the same task by means of a surface-generated electrode polarity reversing current.

Sacrificial anodes comprise an alloy of either zinc or aluminium in the form of blocks mounted on steel bars or tube welded to the structure or on bracelets bolted round members or other tubular components. Impressed current anodes may be mounted both on the structure or on the sea bed away from the platform structure.

Pipeline anodes are generally of the sacrificial type and comprise zinc although alloys of aluminium may also be used.

**ANODE BONDING
STRAP**

A strap or wire used in some anode designs to connect the anode to the installation and provide electrical continuity. Without electrical continuity no protection can be provided.

ANTI-SCOUR WALLS

Concentric walls at the base of Doris-type platforms which guard against scouring and foundation deterioration.

ATMOSPHERIC ZONE

That part of the structure above the upper boundary of the splash zone. It is exposed to sun, wind, spray and rain.

B

BARGE

Any one of many types of flat-decked, shallow draft vessels, normally towed by a vessel.

The oil industry has evolved many variations to serve specialised duties such as pipe laying. Many are self propelled and some are similar to the semi-submersible design.

BARREL	Main component (can) of a node.
BARREL	Unit of volume for petroleum products abbreviated as: 1 bbl = 42 U.S. gallons. = 35 imperial gallons (approx.) = 159 litres (approx.)
BARRELS PER DAY	A measurement of the rate of flow of a well, the total amount of oil produced or processed per day Abbreviation is bpd, sometimes b/d.
BLOWOUT	An uncontrolled flow of gas, oil and other well fluids from the well into the atmosphere/water.
BLOWOUT PREVENTER	A high-pressure valve, usually hydraulically operated, fitted to the top of the casing of a drilling well to prevent an accidental blow-out of oil or gas. Also known as "BOP Stack".
BOP	Abbreviation for blowout preventer (see blowout preventer).
BOTTLE	Corner leg incorporating pile sleeves the upper section of which is usually cone shaped.
BRACE	See "member".
BRACELET ANODE	Anode for cathodic protection of any cylindrical component. It comprises several zinc or aluminium alloy blocks attached to a steel bracelet which is welded, or bolted round and bonded to the component.
BREAKWATER WALLS	Walls in splash zone, generally comprising arrays of concrete holes which dissipate waves and thus protect the structure within the wall area. See also Jarlan Wall.

C

- CAISSON (1) Hollow metal tube descending from the platform into the water for the uptake of water or the discharging of unwanted products, e.g. oily water or drill cuttings.
- CAISSON (2) A watertight chamber for ballast/oil storage or part of a stabilising column on a barge/semi-submersible unit.
- CALM Catenary Anchor Leg Mooring - A type of Single Point Mooring (SPM) usually with six anchors laid radially from the buoy.
- CAN A single length of circular section steel tube between two circumferential welds forming part of the leg or member of a jacket.
- CASING Steel lining used to support the sides of a well, to exclude unwanted fluids, and to provide means for the control of well pressures and oil or gas production.
- CIRCUMFERENTIAL WELD A weld connecting two cylindrical items, butted together.
- CELLAR DECK Lower deck of a production platform, below the drilling deck - usually the first working level above sea level.
- CHORD A through or continuous member to which braces intersect. See also 'Leg'.
- CHRISTMAS TREE Assembly of valves and fittings located at the head of a well to control the flow of oil and gas.

CONDEEP A concrete gravity platform consisting of a base of dome - roofed storage tanks (typically 16) with additional cells extending upwards to form legs supporting the deck structure. Examples include: (3 legs) Beryl A, Brent B, Brent D, Frigg TCP2; (4 legs) Statford A, B and C. An example of a condeep structure is illustrated in Figure 2 opposite.

CONDUCTOR The first (outside) casing string of a borehole. On a production platform, the conductor extends from the surface to blow-out preventer and some distance into the bedrock and serves to protect the riser.

CONDUCTOR GUIDE A guide through which conductor pipe passes during drilling operations and which supports it against the action of the sea. Refer to Figure 3 on page 8.

CONE A section of tubular steel of truncated cone shape, forming the transition between leg or brace section of different diameters.

D

DERRICK The steel structure used to handle the drill string/ casing and other equipment which has to be raised or lowered during well-drilling operations.

DIAPHRAGM WALL Radial concrete wall on Doris-type concrete platforms to join adjacent anti-scour walls or to strengthen the central column.

DORIS
(C.G. DORIS) A group of concrete gravity platforms with an arrangement of vertical, concentric shells joined by radial walls to form a large diameter manifold structure. The deck structure is supported on columns extending up from the outer walls and the innermost cylinder. Examples include Total MCP01, Frigg CDPI and Ninian Central.

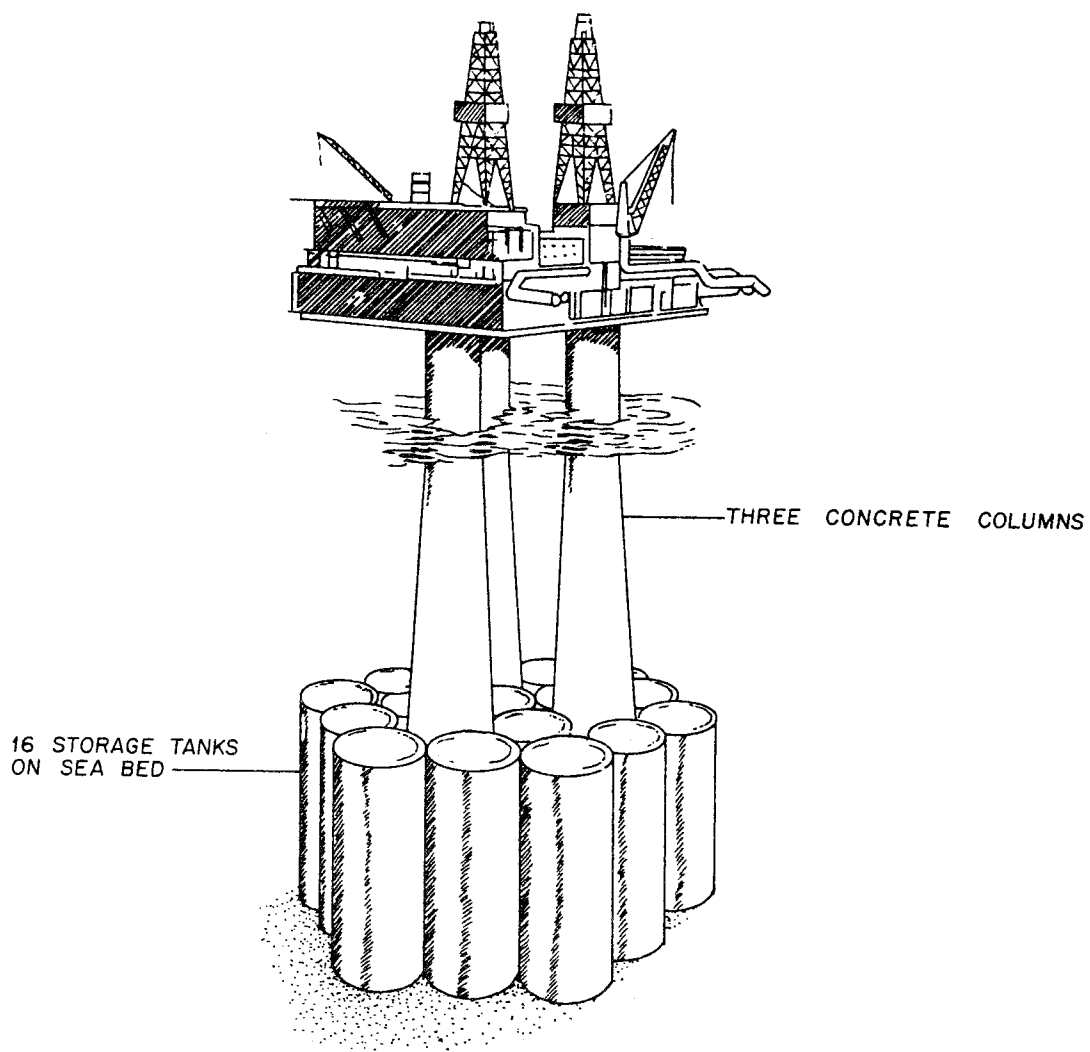


Figure 2: A Typical Condeep Tower-Structure

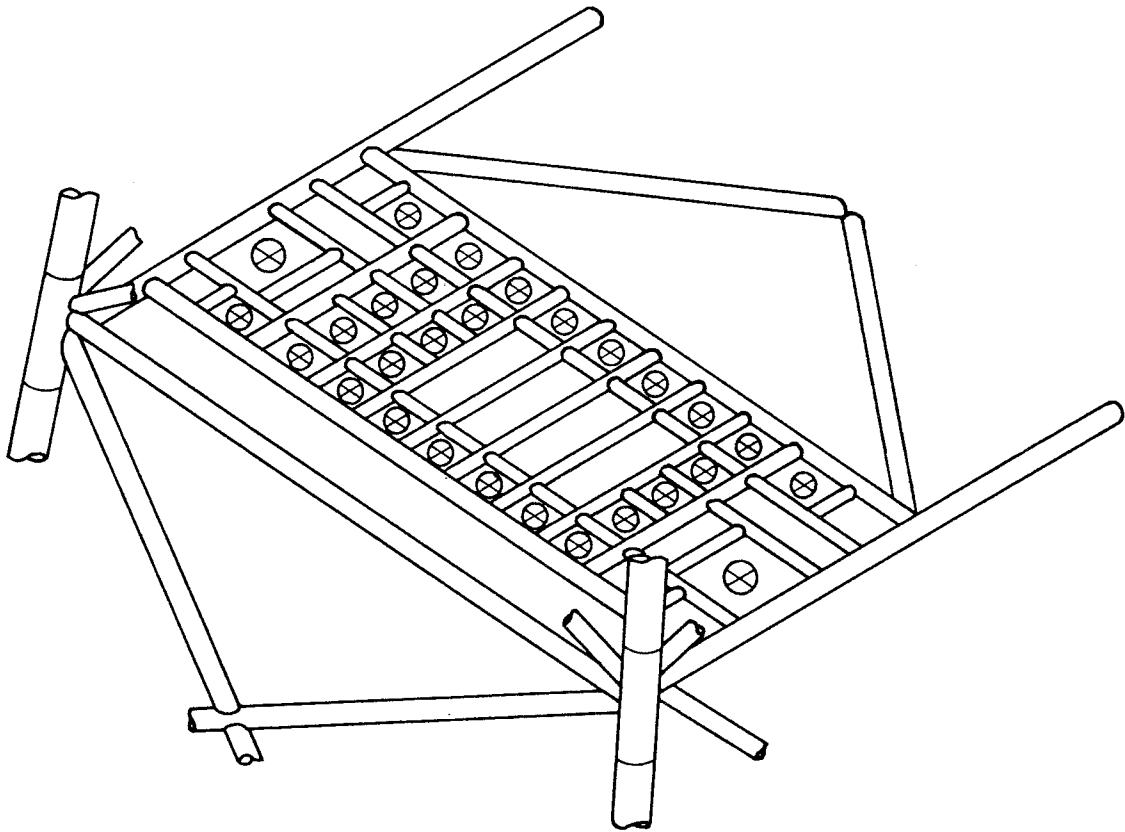


Figure 3: Example of a Conductor Guide Frame Arrangement

DRILL-COLLAR Length of extra heavy drill-pipe. Several drill collars are placed directly above the bit to concentrate the weight of the drill string at the bottom and prevent buckling of the pipe further up.

DRILL DECK The upper deck of a production platform, on which drilling is carried out.

DRILLING RIG Also called "rig" or "exploration rig". A vessel capable of drilling exploration wells. There are three types.

1. Drillships
2. Semi-submersibles
3. Jack-up rigs.

DRILL PIPE Steel pipe used for carrying and rotating the drilling tools in a well.

DRILLSHIP A vessel custom-built or converted for drilling. Generally, it has a drilling derrick over a central moonpool and dynamic positioning to maintain location. Typically it may drill in depths over 1500m.

DRILL-STRING The column of drill-pipe and drill-collars screwed together, at the end of which the bit is screwed.

E

ELSBM Exposed Location Single Buoy Mooring, (see SBM). The mooring hawser and cargo loading hose are stored on drums when the berth is unoccupied.

F

FIXED OFFSHORE INSTALLATION A fixed structure located offshore in shallow or deep water supported by the sea bed soils and not connected structurally to land.

FLARE BOOM A steel structure at the end of which unwanted gas can be burnt off safely.

FLANGE A bolted connection for joining two sections of pipe. Commonly found on risers.

FSU Floating Storage Unit - A floating unit (converted tanker) connected to a permanent mooring system for the continuous storage of produced oil.

G

GRAVITY STRUCTURE A steel reinforced concrete, or concrete and steel hybrid, structure supported directly on the seabed, by its own weight, without pile foundations but provided with a shear key skirt. Often has large storage tanks at its base, with one to four columns supporting the deck.

GROUND ANCHOR A bracket placed around a pipeline and held in place by steel piles. Holds pipeline in place.

GROUT PIPE Pipework used at installation to carry cement to the annular space between the piles and their sleeves to stop any movement between the two.

GUIDE FRAME A horizontal, tubular steel frame, forming part of a steel jacket, through which the conductors pass. Guide frames may be located at each horizontal framing level in the jacket, and prevent excessive sideways movement of the conductors.

H

HELIDECK An area on a production platform, drilling rig or ship designed to permit helicopter landings.

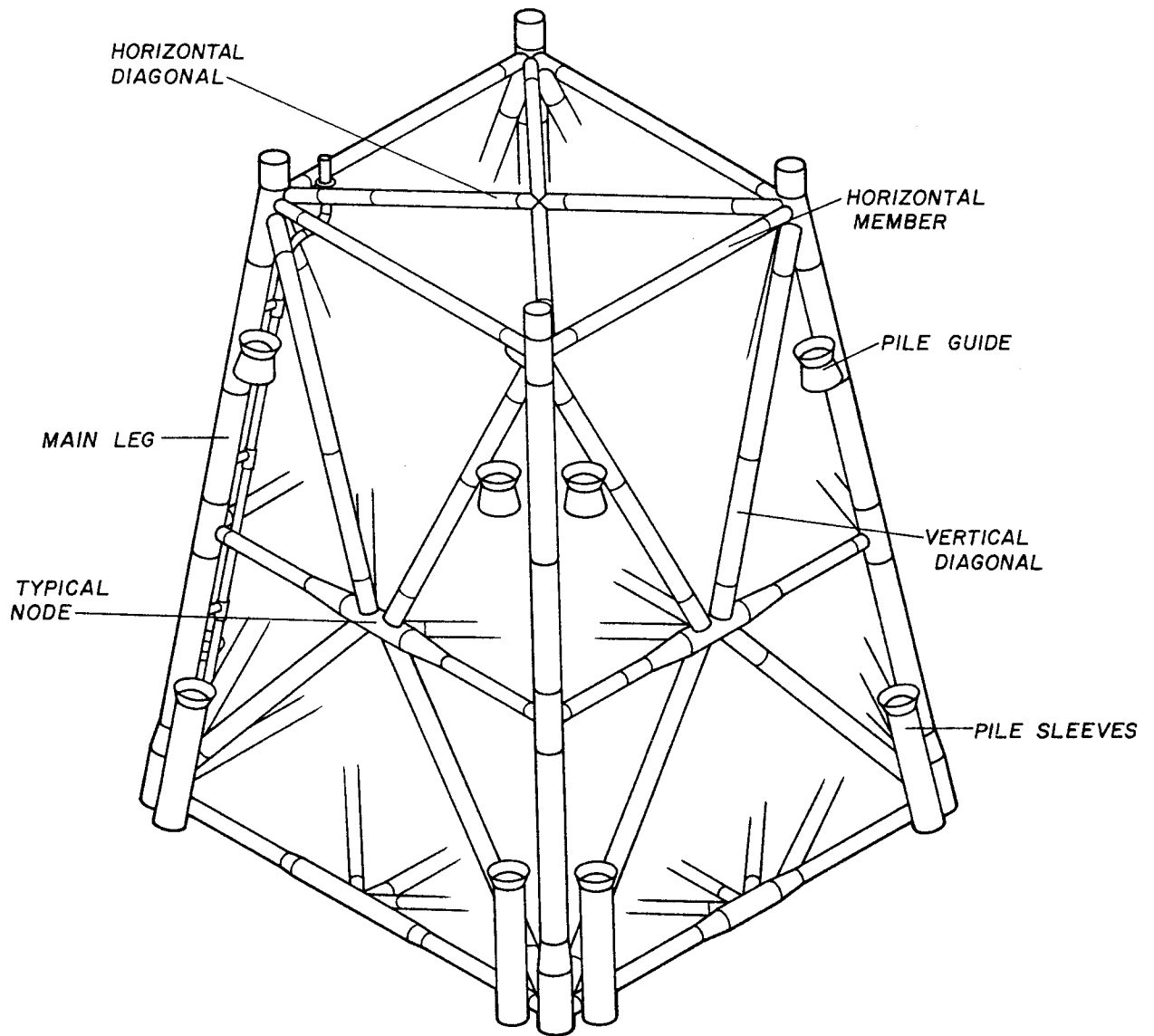


Figure 4: Typical Steel Structure Terminology

I

- INSTALLATION**
- 1) Legal term for a mobile or fixed, production or accommodation platform. (For legal definition see Oil and Gas Enterprise Act 1982).
 - 2) Same term used when 'Setting' the steel jacket or concrete structure on its location.
- IMPRESSED CURRENT**
- A current introduced to steel or a steel and noble metal galvanic cell to reverse the polarity of the two electrodes and ensure protection of the steel from corrosion.
- IMPRESSED CURRENT ANODE**
- An element of noble metal, typically coated in platinum, used as the positive electrode in a cathodic protection system. The platform steel becomes the cathode but only when the current, supplied from a platform DC power source, is passed between them to reverse their original polarities.

J

- JACKET**
- The supporting structure of a steel production platform, made up of legs, members and guide frames. The term "jacket" originally applied to steel platforms piled through the legs (which then formed a jacket around the pile) but is now used loosely for the supporting structure of any steel platform.
- JACK-UP RIG**
- A drilling barge fitted with extendable legs. At the drill site the legs are lowered to the seabed and the barge jacks itself up till it is clear of the water. It may be used in shallow water down to 60m.
- JARLAN WALL**
- A patented design of concrete breakwater wall, consisting of a perforated wall with an enclosed hollow wave chamber behind. The holes in the wall are referred to as "Jarlan Holes".

"J" TUBE A curved tubular conduit installed on a platform to support and guide one or more pipeline risers or cables, hydraulic control lines, electric cables, etc.

L

LAZY - S A submarine hose system in which the correct configuration is obtained by adjusting the buoyancy of the tanks or by submarine floats.

LEG The main vertical component of a steel jacket. A leg is constructed from a number of "cans" welded together. It can be called a chord in a weld inspection context.

LIQUIFIED NATURAL GAS (LNG) Oilfield or naturally occurring gas, chiefly methane, liquefied for transport purposes.

LIQUIFIED PETROLEUM GAS (LPG) Light hydrocarbon material, gaseous at atmospheric temperature and pressure, held in the liquid state by pressure to facilitate storage, transport, and handling. Commercial liquefied gas consists essentially of either propane or butane, or mixtures thereof.

M

MEMBER A component of a steel jacket, made from tubular steel. It may be horizontal, vertical or diagonal. However a through or continuous member is a 'Chord' and an incoming 'member' is a 'Brace'.

MUDLINE The sea floor or seabed at the location of interest.

N

NODE A point on a welded steel structure where two or more members meet. It consists of a barrel as the main body with one or more stubs to which other members are welded. They can be part of a leg or a member. For node structure terminology refer to figures 5 and 6 opposite.

P

PEDESTAL CRANE A large, swivelling crane mounted on a platform or ship and used for general purposes, e.g. supplies.

PILE Steel column driven into seabed to secure structures on the seabed. Refer to figures 7 and 8 overleaf.

PILED STRUCTURE A jacket constructed from tubular steel, secured by tubular steel piles driven into the seabed around the legs.

PILE GUIDE A short steel cylinder (with an open cone uppermost) in which the pile is supported before and while it is driven into the seabed. Pile guides are mounted in clusters around each leg at three or more levels. Often removed on completion of the piling operations.

PILE SLEEVE A steel cylinder attached to the bottom of a jacket leg, which holds the top of a pile after it has been driven into the seabed. Pile sleeves are mounted through shear plates to form an integral part of the structure in clusters around the bottom of each leg.

PIPE Oil-field tubular goods, generally classified as casing (including liners), drill pipe, tubing, or line pipe.

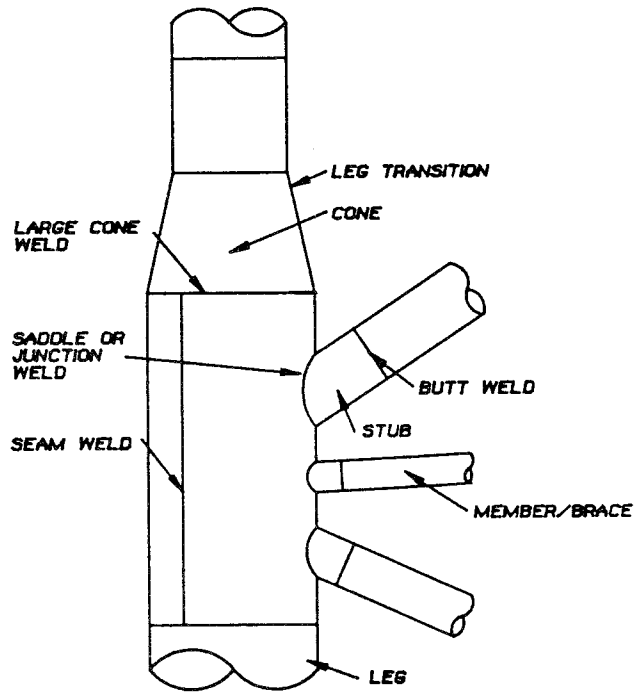


Figure 5: Node structure terminology, example of leg elevation

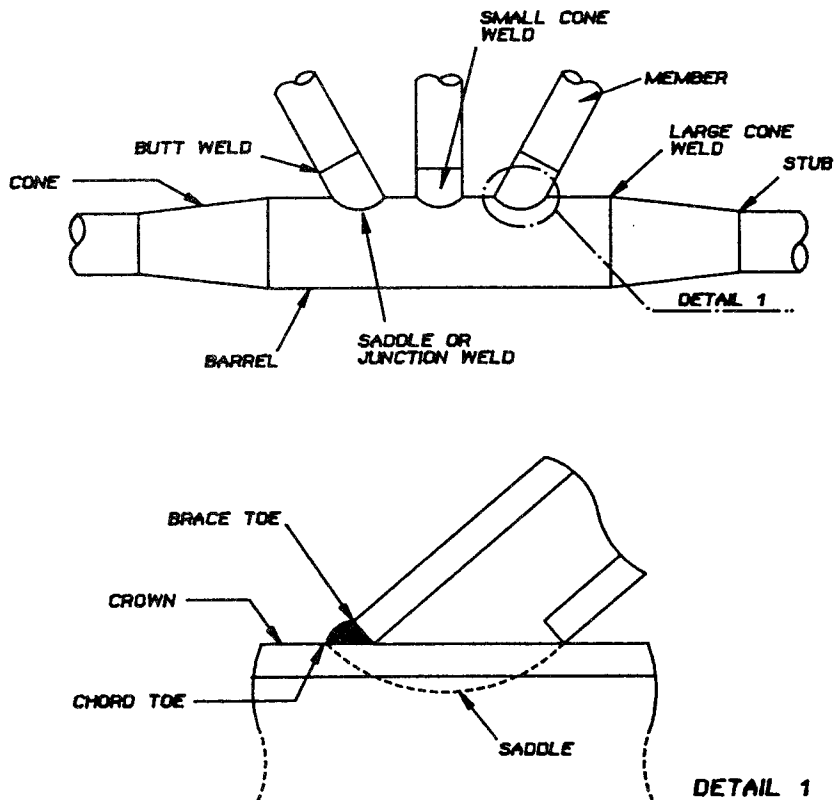


Figure 6: Node structure terminology, example of horizontal member elevation

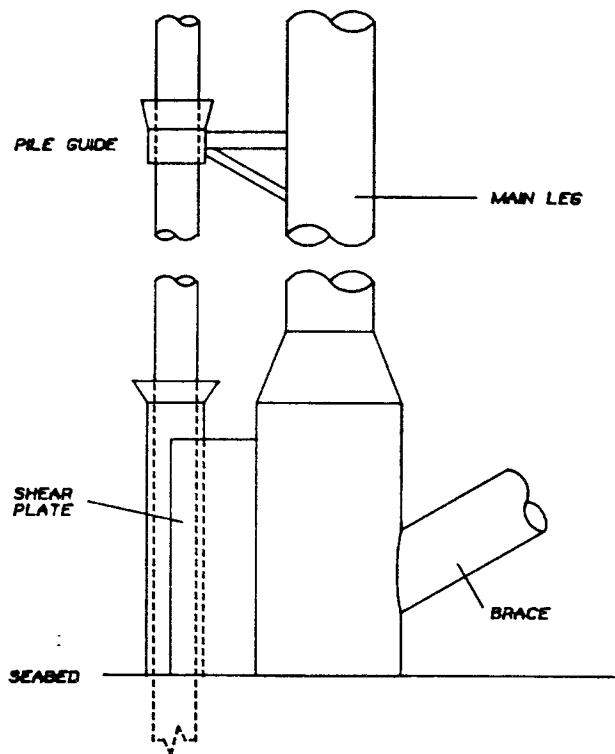


Figure 7: Example of steel piles placed around main leg and hammered into seabed. There are several piles per leg

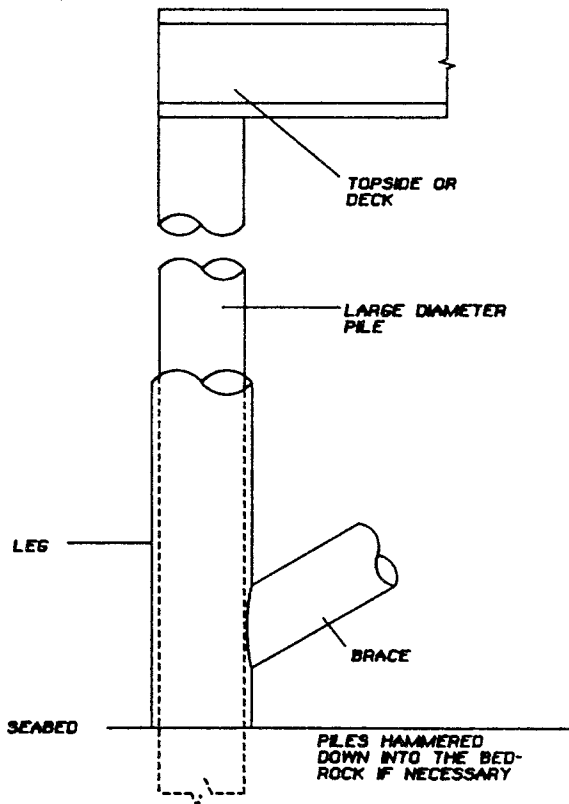


Figure 8: Example of large diameter pile driven into seabed through main leg. The topsides or deck are then welded into the pile and not the main leg. This form of pile is used in shallow water only.

PLEM Pipeline End Manifold. A manifold attached to the end of a production pipeline at a loading tower (SPM).

PRODUCTION That phase of the petroleum industry that has to do with bringing the well fluids to the surface and separating, storage, gauging, and otherwise preparing the product for the pipeline; also the amount of oil or gas produced in a given period.

PRODUCTION PLATFORM (See Installation Legal Term) A permanent or semi-permanent offshore installation providing a drilling base, production - facilities and accommodation. The three basic types are:

1. Piled structures
2. Anchored structures
3. Gravity structures

PRODUCTION STRING The inside string of casing or tubing in a production well.

R

REBAR Reinforcing steel bar used in concrete structures. Also mesh used to strengthen the concrete weight coat of a pipeline.

RETROFIT ANODE Sacrificial anode fitted to a pipeline or platform after installation to provide corrosion protection.

RING STIFFENERS Flat rings welded round a leg or member to enhance its load bearing capabilities.

RISER A vertical pipeline extending vertically the full height of the jacket and used for transporting oil or gas. Production Risers carry oil or gas up from the wellhead while Export Risers take the processed oil or gas down the pipelines.

RISER ANCHOR CLAMP Metal bracket to attach riser to the jacket.
(However, sometimes the riser is electrically insulated from the jacket. Therefore there is no steel to steel contact).

RISER CLAMP Guide to hold riser configuration and allowing for vertical movement.

RISER PROTECTION FRAME An open steel framework covering the risers on certain types of platforms. It protects the riser from damage. Some risers are protected simply by the structure members surrounding them.

S

SACRIFICIAL ANODE A section of metal more active than steel which is placed in contact with an underwater steel jacket to protect the structure from corrosion. Zinc and aluminium alloys are commonly used offshore. A current flows from the anode to the steel, so that the steel becomes cathodic. Corrosion only takes place at the anode.

SALM Single Anchor Leg Mooring - A type of Single Point Mooring (SPM) with a single large anchor.

SATELLITE WELLS Secondary wells drilled away from the production platform from which feeder lines carry the oil to an underwater manifold or directly to the platform.

SBM A Single Buoy Mooring, used for loading oil into tankers in the open sea.

SEATANK A concrete gravity platform consisting of a square cellular caisson with 2-4 columns supporting a steel deck. Examples include: Brent C, Frigg TPl, Cormorant A.

SEMI-SUBMERSIBLE RIG A mobile service installation (usually self-propelled) mounted on submerged buoyant pontoons. It maintains position with several large anchors or dynamic positioning. It can work all year round in depths of up to 300m.

SPAR A type of SPM incorporating storage facilities so that production need not be shut off if bad weather prevents tanker loading.

SPLASH ZONE The zone of a structure or pipeline which is alternately in and out of water, due to the influence of tidal action, winds, and waves. That part of the structure between the crest level of the fifty year wave, superimposed on the level of the highest astronomical tide and 10 meters below the level of the lowest astronomical tide.

SPM Single Point Mooring - used for loading oil into tankers in the open sea. It allows the tanker to take position so as to present the least resistance to the prevailing conditions. Types include:

- ALP : Articulated Loading Platform
- CALM : Catenary Anchor Leg Mooring
- ELSBM: Exposed Location Single Buoy Mooring
- SALM : Single Anchor Leg Mooring
- SPMT : Single Point Mooring Tower

SPMT Single Point Mooring Tower. A type of Single Point Mooring (SPM) in which the tower is fixed to the seabed.

SPOOLPIECE See pipeline section.

STEEP - S A submarine hose system in which configuration is achieved with one buoyancy tank of the correct size which is blown dry after installation.

STORAGE DOMES Tanks at the base of a gravity structure which serve as storage for oil, water or drilling mud.

STUB A short section of tubular steel joined to a leg or member at a node. The stub takes up the curvature of the leg or member so that a bracing member may be butt-welded to the stub.

SUBMERGED ZONE The zone of a structure which extends downward from the lower boundary of the splash zone and includes that portion below the mudline.

SURF ZONE That portion of the pipeline which may be subject to breaking wave action, where it crosses the beach at its onshore end.

SUPPORT COLUMNS The concrete or steel columns supporting the deck in a gravity structure.

T

TEMPLATE (Subsea Well Template) - Structure placed on the seabed through which production wells are drilled by a jack-up or semi-submersible drilling rig.

TENSION LEG PLATFORM (TLP) A particular type of anchored structure consisting of a floating platform moored by hollow, steel tension legs to foundation templates on the seabed. Each leg is held in tension eliminating roll, pitch and heave but allowing some surge, sway and yaw. Refer to Figure 9 overleaf.

TUBULAR

A hollow, steel, cylindrical component forming part of a structure. Examples are legs and members. Can be (a) seamless - pipe
(b) seamed - pipe
(c) formed by the welding together of cans

V

VALVE

A device used to control the rate of flow in a line, to open or shut off a line completely, or to serve as an automatic or semi-automatic safety device.

W

WELLHEAD

A wellhead is the termination point of the well casing. Its function is to provide support to both the well casing below it and the christmas tree on top of it (or the B.O.P. on top prior to well completion). In onshore operations the wellhead is located on the surface, in offshore operations the wellhead may be located either on the seabed or at sealevel.

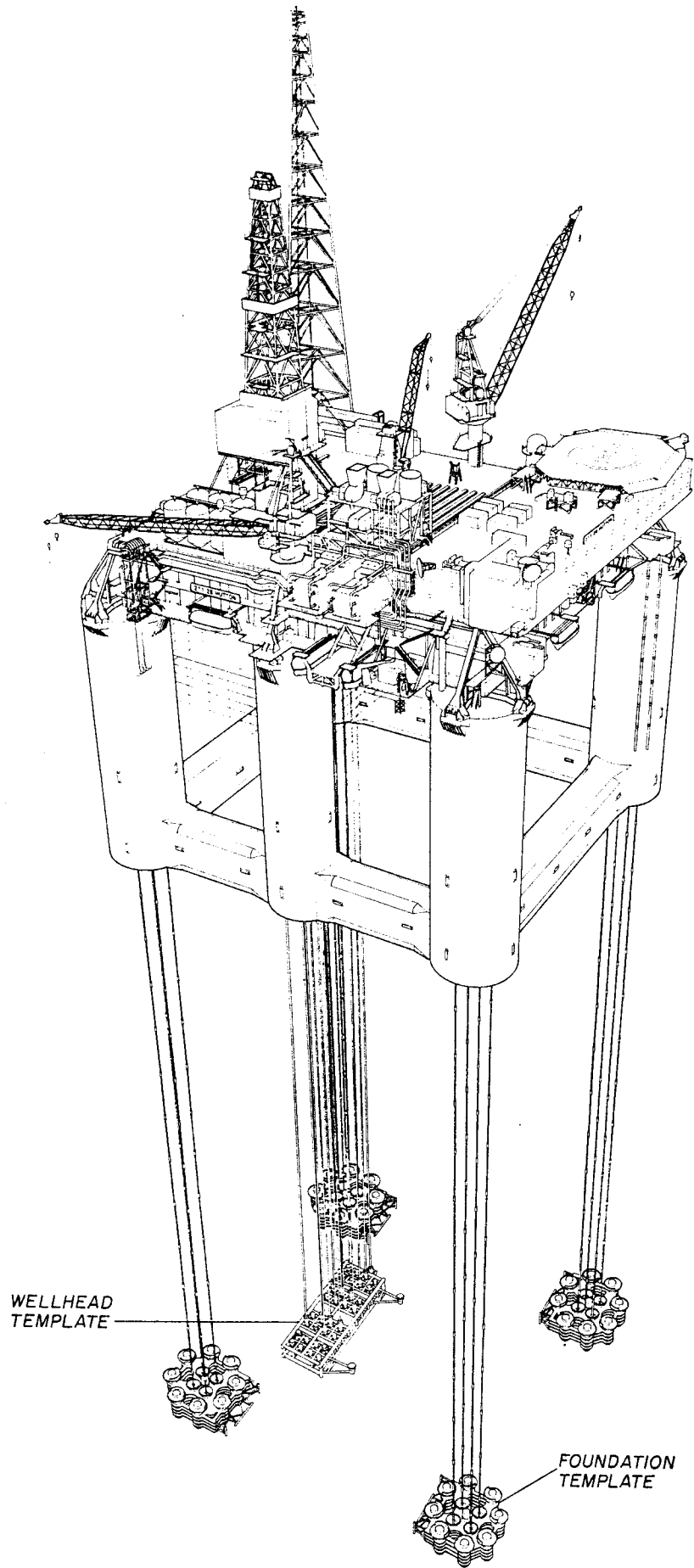


Figure 9: Tension Leg Platform (TLP)

1.2 PIPELINES

<u>Term</u>	<u>Definition</u>
A	
ANCHOR PIPELINES	Pipelines laid on the sea bed and held in position by mechanical anchoring devices.
ANTI-CORROSION WRAPPING	An electrical insulator (either glass fibre reinforced bitumen or thin film epoxy applied to the outside surface of the pipe.
B	
BALL JOINT	A ball shaped joint in a pipe or shaft which allows a degree of movement between sections. Often used at the joint of the marine riser to the top of the BOP stack.
BALL VALVE	A control device, consisting of a bored sphere in a socket, for throttling or shutting off fluid flow. The flow is stopped when the bore is rotated to a position at right angles to the flow.
BLANK FLANGE	See Blind Flange
BLIND FLANGE	A flange placed at the end of a pipe before it is connected up. It has a solid steel plate attached to it to keep water out of the pipe which is removed before the tie-in. (Also called Blank Flange).
BRISTLE PIG	A specially designed pig, with a mild abrasive action, for pipes that cannot tolerate scratching, such as stainless steel, fibreglass and P.V.C.

BUCKLE ARRESTOR	A metallic sleeve placed around a pipe, usually at specified intervals in order to reinforce sections of the pipeline during pipe-laying operations and prevent buckling.
BULLNOSE	A bullet shaped plug on the end of a pipeline which allows it to be pushed into and sealed onto a bell mouthed port (bullport) in the wellhead cellar. It is removed after installation.
BULLPORT	The receptacle for the bullnose of a flowline in a subsea production system.
BURY BARGE	Vessel used specifically to bury pipelines by towing a bury sled alongside the pipeline which utilises its "claw" to bury the pipe.
BURY SLED-	See Jet Sled.
BUTTERFLY VALVE	A throttling or shut off device for large flows utilising a flat plate which can be rotated parallel (to open) or perpendicular to (to shut off) the flow.
C	
CAP	Dome shaped closing piece on first section of pipeline laid. It keeps water out of the pipe to aid buoyancy during laying operation.
CHOKE	A restricting orifice controlling fluid velocity in a pipe.
CLADDING	Sheet metal wrapped around the field joints of a pipeline and held in position by cladding straps. Bitumen or concrete is then poured through a flap on top of the cladding. The cladding straps and cladding may eventually corrode away, exposing black bitumen covering the field joint.

CLAW A piece of equipment forming part of a bury sled or "jet sled" which uses high pressure water from the "bury barge" to create a suction which dislodges sand and mud around a pipeline and discharges it a distance away, thus trenching the pipeline into the seabed.

COMMON CARRIER PIPELINE A pipeline taking oil from several fields which may be shared by various operating companies. Often owned and operated by an independent company.

COMPRESSOR STATION Generally, gases lose their pressure along distances of pipe. To ensure a maximum flow of gas along a gas pipeline, pressure boosting compressor stations may be included, typically every 70km along the gas pipeline.

D

DEFECTS Some defects on pipelines are also common to other structures e.g. physical damage and corrosion. Others such as span (freespan) are peculiar to pipelines alone. These are listed in the "defects" section 2.2.3.

DOPE A bitumastic coating applied to large diameter pipes before concrete coating.

DOPE STATION A bay at the stern of a lay barge where field joints are completed on welded junctions of pre-coated pipes after x-ray inspection.

F

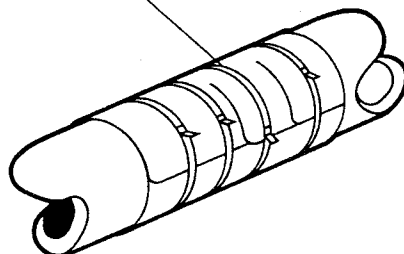
FEEDER LINE A flowline connecting a well to a manifold or associated production system.

FIELD JOINT	Joint between two sections of pipe which is welded and coated on the barge. An illustration of a typical pipeline field joint is shown in Figure 10 opposite
FIELD JOINT NO.	A number on a pipelength in order to identify that section of pipe. The "Field Joint No" is usually on both sides of pipe and provides a good datum for locating features of interest along the pipeline.
FLANGE-UP	Term signifying the project completion, particularly the final connection in a piping system.
FLOWLINE	A small diameter pipeline taking oil from a single well or series of wells to a "manifold" or "gathering centre".
FLOWLINE BUNDLE	A gathered system of flowlines, cables, umbilicals etc. running from a group of wells or manifold.
FLOW METER	A measuring device inserted into a fluid path of calibrated diameter to monitor the fluid flow past the point in gallons per minute. (or barrels per day).
FREE LAID PIPELINE	A pipeline laid on the sea bed which is maintained in position by its own weight.
FREESPAN	See "Defects" section.

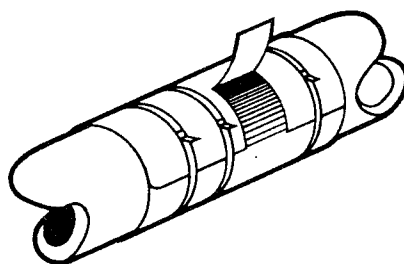
G

GALLON	Measurement of fluid quantity defined in the UK, as the volume occupied by 10lbs of distilled water (U.S.A. Gallon 8.3359 lbs).
--------	---

CLADDING STRAPS



CLADDING STRAPS MAY CORRODE OR
BREAK AWAY ALLOWING THE CLADDING
TO BREAK LOOSE



CLADDING EVENTUALLY CORRODES AWAY,
EXPOSING BLACK BITUMEN COVERING
THE FIELD JOINT

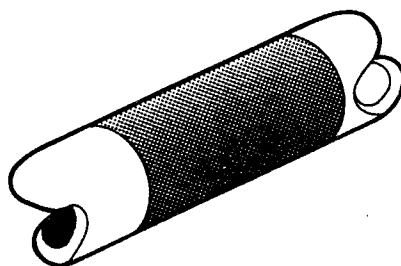


Figure 10: Typical pipeline field joint

GATE VALVE Fluid flow regulating mechanism comprising a piston and guide. The piston is pushed across the fluid path thus throttling the flow, or cutting it off altogether.

GATHERING CENTRE Oilfield installation which receives the production from several wells nearby. It provides facilities to separate the gas and water and to transport the oil to the main storage tanks. The gathering centre is installed on a production platform.

GROUT BAG A bag, pressure filled with grout from a support vessel, to support the spans and stabilise the pipeline or to protect the pipeline from damage.

H

HEADER System of pipework used as a gathering and distribution point. Also known as a manifold.

HOLIDAY A relatively small discontinuity of paint or coating that exposes the substrate metal surface to the environment.

I

INSTRUMENT PIG Pig designed to record irregularities and obstructions inside pipeline. Used to survey newly installed pipeline, or inspect existing pipelines for damage.

J

JET SLED Used from a bury barge to bury pipelines. Tubular steel sled towed by a trenching barge and equipped with water jets and airlifts to excavate the trench and bury the pipeline.

L

- LANDFALL** The first point of contact of an offshore pipeline with land
- LAY BARGE** Self contained pipeline installation vessel. (Also called "pipelay barge"). Used for welding together and laying underwater pipelines. May be a barge or semi-submersible, manoeuvred by a multiple anchor system and equipped with a diving system, helideck, welding and bitumen-coating equipment.
- LAYDOWN HEAD** The section of the pipeline that is lowered to the seabed first during pipe-laying operations.
- LINE PIPE** A seamless pipe tubular manufactured to API specifications and is available up to 18" outside diameter.
This type of pipe may be used on a spool on a reel barge.

M

- MANIFOLD** An arrangement by which production from several wells may be combined in various ways for forwarding through one or more pipelines.
- MATTRESS** A flexible bag laid over a pipeline then filled with grout to anchor it to the seabed. Refer to Figure 11 overleaf.

P

- P. & I.D.** Piping and Instrument Diagram. Process Engineering line diagram indicating pipework and vessels sections as single lines but showing the actual pipe form and positioning and the instruments along its length.

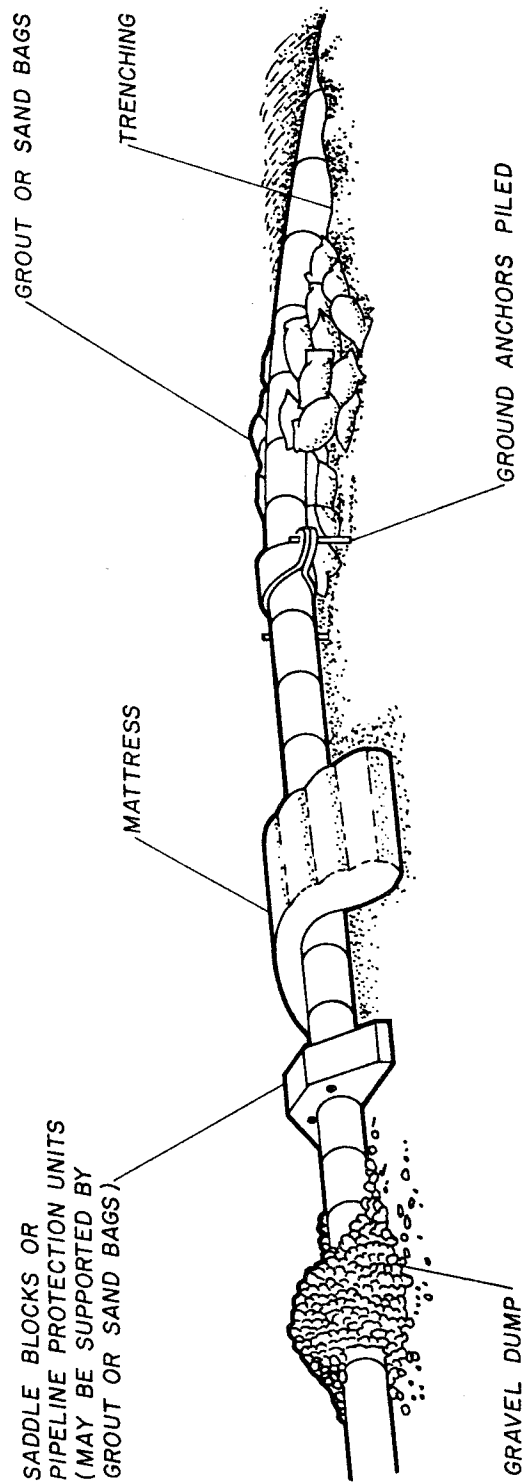


Figure 11: Pipe stabilisation techniques

PIG A cylindrical or spherical device which travels along a pipeline with the fluid flow or under its own power for cleaning and inspection. The name comes from the squealing sound the pig makes in operation.

PIG LAUNCHER/RECEIVER A parallel branch of a pipeline and associated machinery for the purpose of launching and/or receiving pigs, often called the pig trap.

PIG TRAP See Pig Launcher/Receiver.

PIPE GRADE Classification of pipe material by API (American Petroleum Institute) specification. e.g. 5A, 5AX, 5LS. The letters indicate the material as listed in the appropriate specification. This may be followed by another number indicating the Yield Strength of the material (e.g. X65, X70).

PIPELENGTH A section of pipe welded to another to form a pipeline. The length of a pipe is usually 40ft (approx. 12m).

PIPELINE A tubular conduit for carrying produced oil, water, and/or gas between platforms or between platforms and onshore processing facilities.

PIPELINE CONNECTIONS The most common methods of joining pipe sections are welding and mechanical flanged connections. In addition there are specialist proprietary mechanical and welded connectors such as "flexiforge", "Gripper", "Cameron", "HydroBall/HydroCouple", and "Weldball".

PULLING HEAD The section of the pipeline that is lowered to the seabed after completion of pipe-laying operations.

R

- RABBIT** Small plug or pig which is forced through the pipeline to test for, or clear restrictions such as dents or foreign bodies.
- RADIAL CUTS** Cuts in the concrete weight coat of a pipeline to allow flexibility during pipe-laying.
- RAMP BARGE** Lay barge with very long ramp instead of stinger.
- This allows more pipe sections to be welded at once thus reducing the lay time.
- REEL BARGE** Self contained pipeline installation vessel specifically designed to accommodate the use of large spools of line pipe. These reduce the offshore welding required allowing pipelines to be laid very quickly.
- RISER** Sometimes called marine riser, it is a section of pipeline extending from the seabed to the production deck of a platform.
- ROCK DUMP/GRAVEL** Areas of a pipeline covered with rock or gravel. DUMP rock dumps are coarse, larger, and ungraded compared with gravel dumps which consist of graded material with more uniform sized stones of approx. 50mm dia.

S

- SADDLE BLOCKS** Pipeline protection units placed over the pipeline to prevent any damage and to stabilise the pipeline.
- The gaps all around the pipe and any scouring at the base of blocks should be reported during a survey.

SAND BAG A bag, filled with sand and tied on top, to support the spans and stabilise the pipeline or to protect the pipeline from damage.

SIGNALLING PIG This specialised pig deflects arms inside the pipeline or makes electrical contacts to signal arrival at various positions along the pipeline, allowing the progress of different fluid batches to be monitored.

SIZING PIG Spherical pig driven by compressed air used as a means of checking that the internal face of the pipeline is clear of obstruction.

SPAN See "Defects" section.

SPLIT SLEEVE Mechanical clamp used for pipeline repairs. It comprises two cylindrical halves with internal gaskets held by clamps around the repair section.

SPOOL Large reel holding a long length of small diameter line pipe. Used on reel barges, the pipe is simply reeled off into the water. The longer pipelengths used reduce the welding required offshore, hence speeding up the whole operation.

SPOOLPIECE The section of pipeline between a riser and its associated seabed pipeline. It is fabricated specifically to the required size and shape, from measurements supplied by divers inspecting the riser and the pipeline.

STINGER An articulated ramp used off the stern of a lay barge as a catenary support for the pipe being laid. The catenary can be altered using variable buoyancy units along the length of the stinger.

SUB-SEA COMPLETION A method of completing a well or wells whereby equipment controlling oil flow, normally mounted on a surface platform, is housed in a special construction on the sea floor.

SUBSEA SAFETY VALVE A failsafe gate valve operated remotely. It is normally included with the B.O.P. or production tree arrangement.

SURF ZONE Section of pipeline before landfall which is subjected to the action of the waves breaking at the shore.

SURGE RELIEF TANK A large tank openly connected to the pipeline before shut-off valves, particularly at landfall, to relieve the high pressure surge caused by the momentum of the fluid if the valve is shut suddenly.

SUSPENSION See "Defects" section.

T

THROTTLING Causing a reduction in fluid pressure in a pipe (slowing the flow). This is done by obstructing the flow e.g. closing a valve slightly.

THROUGH FLOWLINE (TFL) A method of passing tools and instruments, by wire or pressure, through the flowline.

TIE-IN- Term used for operation of connection of the laid pipeline into the system using specially fabricated spoolpiece sections.

TRENCH A ditch produced on the seabed for keeping the pipeline in position. The width, depth, and an estimate of pipe and the trench bottom in relation to mean seabed level should be given during a pipeline survey.

TRENCHED PIPELINE Pipelines laid in a trench in the seabed, which can be subsequently back-filled to provide protection and maintain the pipeline position.

TRENCHING BARGE (Also called "jet barge" or "bury barge"). Excavates a trench for a pipe or cable to protect it from damage. The trenching is carried out by a "jet sled" or a proprietary ploughing system.

TRUNK LINE Main oil or gas pipeline (as opposed to "flowline").

U

UNDERWATER PLOUGH A wheeled/tracked or skid mounted deep plough dragged/driven along the seabed to dig a protective ditch in which to lay the pipeline.

W

WEIGHT COAT A concrete (or other protective material) coating applied to a pipeline to provide negative buoyancy, and protect the pipeline from damage. The coating is applied onshore before the pipe is transported by supply vessel to the lay barge.

WISHBONE Forked structure at end of bury barge to which hoses for carrying H.P. fluid and returning mud to and from claw are attached.

2. INSPECTION

2.1 EQUIPMENT AND TECHNIQUES

<u>Term</u>	<u>Definition</u>
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A

ALTERNATING CURRENT POTENTIAL DIFFERENCE (ACPD)	See section "Materials and Weld Inspection".
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AREA IDENTIFICATION SYSTEM	System of marking on structure to assist diver in position finding and orientation. Systems in use involve painted markings, single weld bead lettering, attached metal plates and the proprietary "SEAMARK" system.
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B

BARE METAL	Surface finish standard for cleaning. All growths, loose deposits, coatings and other coverings are removed to show solid metal below. Achieved by scraping, brushing, water jetting, etc. (A procedure specifying cleaning should also specify to what standard, eg. Swedish Standard).
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BASE LINE	A survey established with more than usual care, to which subsequent surveys are referred for co-ordination and correlation.
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BATHYCORROMETER	See Roxby Bathycorrometer.
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BRIGHT SHINY METAL	Same as bare metal except that all surface stains have been removed to give uniform metallic sheen. This can be achieved with mechanical brushing or water jetting. (A procedure specifying cleaning should also specify to what standard, eg. Swedish Standard).
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C

CALIBRATION STEP WEDGE	Steel wedge with steps of known thickness from the base for checking calibration of a wall thickness meter.
CALOMEL ELECTRODE	Reference electrode, used in seawater, to check the calibration of a CP meter. Voltage difference between a Calomel Electrode and Ag/AgCl half cell should be 0 to -10mV.
CCIV	Closed Circuit Television system comprises camera, monitor, umbilical, surface control unit, video-recorder and video-typewriter. (see "Video Systems" section).
CENTRE PUNCH	A tool for marking a datum point in, for example, weld inspection. This allows a continuity in the inspection process so that one year's results can be directly compared with another. N.B. should be round headed so as not to initiate additional defect.
CLEANING FOR VISUAL INSPECTION	Marine growth cleared to between 300-900mm around subject. The subject itself may be cleaned to Swedish Standard ST3.
CLEANING FOR NDT	Same as for visual inspection except subject and surrounding 75-100mm should be cleaned to Swedish Standard SA2 ¹ / ₂ .
CLEARANCE OF MARINE GROWTH	PURPOSE: to reduce drag, mass, wave loading, weight, unblock intakes etc., biological corrosion and any other damage which may occur. ACHIEVED: by brushing, scraping, water jetting, etc.

COMB GAUGE See "Contour Gauge".

CONTOUR GAUGE Several lengths of thin metal strip are held together in single file by two metal plates. When the strips are forced against an irregular surface they fill the irregularities and an impression of the surface is taken which can be taken to the surface and studied. Also called "Profile Gauge" or "Comb Gauge".

CP METER A meter that measures the relative potential of a structure, thus allowing the effectiveness of the cathodic protection system to be assessed. There are two main types, (1) "Direct Contact" and (2) "Surface Readout" or "Proximity Meter". (see appropriate headings). (See "Corrosion" section). Calibration of the instruments can be checked by taking readings on surfaces that will give known values (see "Zinc" & "Rusty Iron" calibration blocks) or by checking against a Calomel Electrode.

CP SURVEY Measurements are taken with CP meter at pre-plotted points and possible shielded and unprotected areas of structure to determine the effectiveness of the cathodic protection system.

CVI - CLOSE VISUAL INSPECTION Detailed visual survey of important areas.

D

DATUM Any numerical or known geometrical feature or set of such quantities which may serve as a reference or base for other measurements.

DIRECT CONTACT CP
METER

This is a one piece unit with a contact probe at one end and a digital read-out at the other. The reference half cell is located circumferentially within a vented part of the instrument body. The contact probe is a replaceable shaft of stainless steel with a hardened conical tip. This material contributes virtually no electrical component to the circuit in normal sea water. Measurements of cathode potential are read directly off an illuminated digital display.

DRY GRIT DELIVERY
SYSTEM

This system operates at about 3000 to 7000 psi. The grit is drawn down a large bore air hose limiting it to the air diving range. This system gives a good matt finish on steel surfaces which makes it suitable for photography. The system requires the mobilisation of large stocks of silica sand.

E

EDDY CURRENT
TECHNIQUE

(See section on "Materials and Weld Inspection").

F

FLOODED MEMBER
DETECTOR/FLOODED
MEMBER DETECTION
UNIT

An instrument which uses ultrasonics to determine whether or not a member is flooded.

FLOODED MEMBER
SURVEYS

An ultrasonic NDT technique which uses a flooded member detector to determine whether or not a member is filled or partially filled with water. It is a quick easy survey giving an immediate indication of areas with possible structural faults which can be investigated further after detection.

FLYING PROBE Probe containing silver/silver chloride half cell used in conjunction with surface unit of surface read-out CP meter. Sometimes called a proximity probe.

G

GVI-GENERAL VISUAL INSPECTION A survey of the structure to assess its general condition. This does not generally require cleaning and the objective is to locate any significant damage to the structure such as missing, buckled or dented members, gross cracks, and abrasions.

GRIT BLASTING See Dry Grit and Wet Slurry Delivery System.

GRIT ENTRAINED WATER JET Same as HP water jet but operated at a lower pressure. Grit is supplied either dry in air or wet in sea water (slurry) from a hopper/agitator/ pump system down a parallel rubber hose with the HP water and introduced to the water jet by means of a venturi just before the nozzle of the jetting gun. (See dry grit and wet slurry delivery systems).

H

HAND CLEANING Soft growth can be removed from small areas by sweeping with the hand. Other hand methods are scrapers, wire brushes or rubbing ropes across the surface.

HIGH PRESSURE JET Powerful pump on surface produces a pressure WATER around 10,000 psi which is pumped via rubber hose to a jetting gun held by the diver at the working depth. The gun produces two jets, one a high velocity stream out the front nozzle and the other a retrojet to balance the force produced by the front jet. The high velocity jet can be used to blast any adhering growth or coating off surfaces, (great care is needed when using the system).

M

MAGNETIC IDENTIS	Temporary identification system consisting of idents on magnetic carriers for attaching to local areas to identify them in photographs and to enhance video presentation.
MARINE GROWTH SURVEY	Operators are required to report on type and extent of marine growth on offshore structures. This type of survey is generally carried out as a description of growth at all the areas where work is carried out.
MECHANICAL CLEANING	Involves rotary brushes powered pneumatically or hydraulically. Brushes can be nylon or steel depending on the surface finish required. Nylon rotary scrapers are also available for cutting off stubborn marine growth and cutting through mussel beds. Another mechanical method is the needle gun (see needle gun). These methods are not favoured for high surface finish standard cleaning as they cause peening of the metal surface which may obscure defects or produce spurious indications.
METAL PLATE MARKERS	Platform section identifications cut through a metal plate attached to structural components. Disadvantages - attachments corrode and plates fall off. - difficult to see.
MORGAN BERKELEY RUST READER	A commonly used Direct Contact CP Meter.
MPI - MAGNETIC PARTICLE INSPECTION	See MPI section.

N

NDT - (See MPI, ultrasonics, radiography, eddy current
NON-DESTRUCTIVE and ACPD).
TESTING

Any method of checking for discontinuities in a solid object without causing physical damage or reduction in integrity to the object.

NEEDLE GUN Hand held machine which powers a compact group of vibrating needles. It is a slow method and not often considered a suitable method of cleaning. The major disadvantage is that it can easily worsen a defect by peening over it. However, it can be useful in the removal of bitumastic and epoxy coatings.

P

PAINT MARKINGS Platform section identifications painted on structure. The disadvantage is that paint may come off.

PHOTOGRAMMETRY (See "Photography", Section 2.5).

PHOTOGRAPHY (See "Photography" section). (Also "Photomosaic Technique", "Stand-off Photography" and "Close-up Photography").

PIT GAUGE An instrument used to measure the depth of localised corrosion or pitting. It could be also used to measure the depth of any physical damage such as abrasions.

POWER BRUSH An instrument that consists of one or more rotary nylon or wire brushes. The power to rotate them may be pneumatic or hydraulic. Wire brushes are particularly useful for clearing hard marine growth. However, they maypeen over any surface defects.

PROFILE GAUGE See "Contour Gauge".

PROXIMITY METER (See "CP Meter").

R

RADIOGRAPHY An NDT technique where radiation is passed through the test subject onto a photographic film which produces a shaded "picture" of the subject dependent on the amount of radiation absorbed by or transmitted through the subject thus showing up discontinuities such as cavities and inclusions, (See "Radiography" section).

RETROJET Secondary jet of water directed out the back of a jetting gun to balance the momentum of the water jet out the front.

"ROXBY
BATHYCORROMETER" A commonly used direct contact CP meter.

RULER Ruler with fine scale is used as part of an inspection divers equipment.

"RUST READER" A commonly used direct contact CP meter made by Morgan Berkeley.

RUSTY IRON
CALIBRATION BLOCK Block of rusty iron (used in sea water) for checking calibration of CP meter. Rusting iron should give a reading of -400 to - 650 millivolts with respect to silver/silver chloride half cell.

S

SCOONES HOUSING Water/pressure proof body that is used to house a camera so that it may be operated under water.

SCRAPER Flat metal or nylon tool used by hand or on rotary mechanically driven equipment for removal of stubborn marine growth or deposits. It can cause surface marking on steel if not used properly.

"SEAMARK" Trademark for platform location identification markers black on luminous yellow plates with anti-fouling coating which are securely attached to structural components with tough reinforced plastic bands.

SEA PROBE (See Wall Thickness Meter)

STANDARDS The specifications set to achieve uniformity of inspection results. Cleaning for instance is done to relevant standards, the most common being the Swedish SA2 1/2 and ST3, (see Swedish Standards).

STEREO PHOTOGRAPHY See "Photography" section.

SURFACE READOUT CP METER When direct readout under water is inappropriate or where rapid surveys are required without needing to make an individual contact point, a surface unit attached to a wandering reference half cell is used.

This is the type of equipment used for CP surveys with ROVs.

SWEDISH STANDARDS For cleaning. Removal of all surface deposits, ST3 growths and coatings down to a pronounced metallic sheen on solid metal.

SA2 1/2 Same as ST3 but all staining to be removed as well as leave a uniform metallic colour (dull matt grey metal).

T grade refers to wire brush cleaning, A grade to the use of grits.

T

TAPE MEASURE

A measuring tool used as necessary. Standard part of diver Inspector's equipment.

THORPE GAUGE

A commonly used pit gauge. Its main disadvantage is that the readings are imperial, not metric.

U

ULTRASONIC TESTING

An NDT technique where pulses of sound energy (beyond sonic frequencies) are passed through the test piece. Discontinuities are located when the sound bounces back off them. The travel time of the sound pulse is recorded and as the sound velocity and direction are known the discontinuity can be pinpointed with accuracy. The simplest ultrasonic technique used offshore is in the measurement of wall thickness of pipes and plates where the sound is "bounced" off the opposite face from that on which the wall thickness meter is placed and the pulse travel time is converted to a distance by the instrument which gives a readout in millimeters. (See "ultrasonics" section).

UT

Ultrasonic Testing (See "Ultrasonics" section).

W

WALL THICKNESS METER

Simple ultrasonic compression probe and interpretation instrument enclosed in one water/pressure resistant casing with a digital readout showing thickness of steel walls (pipes, plates, etc.) in millimeters. Usually accurate to about 0.2mm. It is a very important device for corrosion and erosion monitoring. The most common wall thickness meter in use is the Seaprobe SP200, which is a cylindrical device. One end is pressed against the point of measurement and the other gives an L.E.D. readout of the wall thickness. Its calibration can be checked offshore, (see Calibration Step Wedge and Ultrasonic Testing).

WALL THICKNESS SURVEY Points of measurement are marked at regular intervals on subject and readings taken with wall thickness meter. It is a method of corrosion and erosion monitoring. Particularly useful on pipe bends and risers.

WATER JETTING High pressure water jetting (10,000-15,000 psi) is the most extensively used cleaning method for the removal of general marine growth. It is also effective for intense cleaning where all but the most stubborn deposits and coatings will be removed.

WELDING INSTITUTE GAUGE An instrument for taking various weld measurements, eg. throat depth, weld prep. angle, etc. It can also be used as a pit gauge.

WELD BEAD MARKINGS Platform section identification made with letters written with single weld beads welded to structural components.

Disadvantages - irregular profile
creates stress raisers.
- difficult to find.

WET SLURRY DELIVERY SYSTEM This system does not need air, unlike the dry grit system, so can be used at greater depths. However, its cleaning rate is much less than dry grit because of reduced volume delivery and frictional losses down several hundred feet of hose. The most recently developed slurry systems utilise mechanical movers in the delivery hose which have substantially improved saturation diving range cleaning. This system requires the mobilisation of large quantities of silica sand.

WIRE BRUSH

Brush with wire bristles either hand held or rotary equipment to give a good standard of cleaning of metal surfaces. Main disadvantages are slow rate of cleaning and bristle action canpeen over defects or cause spurious indications for MPI.

Z

ZINC CALIBRATION
CHECKING BLOCK

Block of zinc (used in sea water) for calibration of CP meter. Zinc should give a reading of -1000 to -1050 millivolts with respect to silver/silver chloride half cell.

2.2 MAGNETIC PARTICLE INSPECTION

Term

Definition

A

AC

Alternating current. An electric current which periodically reverses its direction in a circuit. The advantages of AC for MPI are:

1. Skin effect where it creates maximum flux at the surface of the magnetised item.
2. It can accommodate changes of section in material.
3. It makes demagnetisation possible.
4. The equipment is lighter and cheaper.
5. Because it also creates an alternating magnetic field the particles vibrate slightly and are more readily transported to discontinuities.

B

BACKGROUND

The general appearance of the surface on which inspection is carried out.

BLACK LIGHT

Near ultra-violet radiation used for exciting fluorescence. The wavelength is typically 365 nm (3650 Angstroms). A filter is used to suppress visible and far UV light.

BLACK LIGHT FILTER

A filter which suppresses visible light and ultra-violet radiation other than black light. Commonly known as a "Woods Filter".

**BURMAH CASTROL
STRIP**

A brass Strip with longitudinal artificial defects used to provide an indication of magnetic field strength. The defects show up at particular field strengths when coated with ink and illuminated with black light. These strips are used to check for residual magnetism and to confirm that the applied field is sufficiently strong for MPI. (See "Reference Pieces").

Can also be used with white light inks.

C

CARRIER FLUID

The fluid in which magnetic particles are suspended to facilitate their application.

**CIRCUMFERENTIAL
MAGNETISATION**

Magnetisation which establishes a flux around the periphery of a component.

CLEANING FOR MPI

The area to be inspected should have all marine growth, rust, scale or protective coatings removed for a minimum of 100 mm either side of the weld. Heavy marine growth is cut back either side to permit TV surveillance. The region to be inspected must be cleaned to matt finish.

COERCIVITY

When a ferromagnetic material is magnetised to its saturation value and the applied field is removed, a residual magnetism or REMANENCE is left. The COERCIVITY is the reverse field which must be applied to reduce the remanence to zero, i.e. to completely demagnetise the material. It can be interpreted as the ease of demagnetisation of a metal. (see also permeability, retentivity).

COIL	A current-carrying cable wrapped around the component to be inspected in order to induce a magnetic field within the component. The cable may have quick-fit connections to allow it to be coiled around a component with no free ends, such as a bracing member.
CONTACT PADS	Metal pads, usually of copper braid, placed on electrodes to give good electrical contact, thereby preventing damage to the component under examination.
CONTINUOUS MAGNETISM TECHNIQUES	Where the magnetising means is applied continuously throughout the test. Has to be used on materials with low retentivity where any residual magnetism may not be sufficient to perform MPI.
CONTRAST	The difference in reflectivity or colouration between the component under examination and the defects as shown by the magnetic particles.
CONTRAST PAINT/ CONTRAST AID	A coating applied to a surface to improve contrast by providing a more suitable background for the ink. Rarely used underwater, since fluorescent ink provides sufficient contrast. Onshore, black ink on a white background is often used.
CORE	That part of the magnetic circuit which is within the winding of a coil.
CURRENT FLOW MACHINE	An arrangement for supplying AC, DC or rectified AC current for magnetising components by the current flow, coil, parallel conductor or threader bar techniques.

**CURRENT FLOW
TECHNIQUE**

A technique for magnetising by passing a current through a component via prods or clamps. The current may be AC, rectified AC or DC. The magnetic field generated is perpendicular to the current flow.

D

DIRECT CURRENT

An alternative to AC in magnetisation. In practice, "DC" is often used to describe halfwave - rectified AC.

DC gives better detectability of sub-surface defects than AC but demagnetisation is not possible. DC is not normally used in underwater MPI.

DEMAGNETISATION

The removal of any residual magnetisation, usually by wrapping a coil around the component to be demagnetised, applying full AC and reducing the current to zero. Demagnetisation is carried out after MPI and may be necessary beforehand if residual magnetism is present.

DEMAGNETISING COIL

A coil of wire carrying alternating current which is used for demagnetisation.

DETECTING MEDIUM

The detecting medium consists of magnetic particles either in the form of a dry powder or in a liquid carrier, or ink. The method most used in underwater MPI is magnetic particles suspended in a fluorescent ink which shows up under black light.

DIFFUSE INDICATIONS

Indications that are not clearly defined, e.g. indications of sub surface defects

**DRY POWDER-
TECHNIQUES**

The application of magnetic particles without the use of a liquid carrier.

E

ELECTRODE

A conductor by means of which a current passes into or out of the component under examination.

ELECTROMAGNET

A magnet formed by passing a current through a coil wrapped round a soft iron core, the ends of which act as the poles when the core is magnetised by the coil. The major disadvantage is it needs a power supply but because soft iron has a low retentivity the magnet can be "switched off".

F

FERROMAGNETIC MATERIAL

A material from the group iron, nickel and cobalt and some of their alloys. These are the only materials which can be magnetised to any significant degree.

FLASH MAGNETISATION

Magnetisation by a current flow of very brief duration.

FLUORESCENT INK

A carrier fluid for magnetic particles which fluoresce, ie. glow, when illuminated with black light. The ink is supplied as an orange-brown powder which is then mixed with kerosene before application. In use it is applied to the component to be inspected by a dispenser attached to the ultraviolet lamp.

FLUX DENSITY

The number of lines of magnetic force (often called lines of induction) passing through unit area. Also called magnetic induction. The flux density in a medium is the product of the applied field and the permeability of the medium. Units are gauss in the cgs electromagnetic system of units and the Tesla in the SI system. Flux density for MPI is typically 7200 - 12000 gauss or 0.72 - 1.2 Tesla. One Tesla = 10^4 gauss. A discontinuity will only show up if it lies across the lines of force. (see indication orientation).

FLUX DENSITY INDICATOR	A means of indicating the relative strength of a magnetic field. The most commonly used is the Burmah-Castrol strip.
FLUX LEAKAGE	Where a magnetic field exists within a ferrous metal the magnetic flux (line of force) will jump over and concentrate at any discontinuity in the metal, for instance a crack. This is known as flux leakage, and is the phenomenon on which MPI depends, ie. where lines of magnetic force have to leave the metal body at a North Pole and enter at a South Pole. (see indication orientation).
FLUX PENETRATION	The depth to which a magnetic flux is effective in a component. For practical magnetic particle flaw detection this depth is quite small, and is dependant upon the extent of the defect, the magnetic particles and the magnetising technique used.
FURRING	A build-up of magnetic particles due to excessive magnetisation of the component under examination.
I	
ILLUMINATION	All inspection should be carried out in good illumination of the proper type (black for fluorescent inks).
INDICATION	Any discontinuity found during inspection is called an indication, the classification of which is determined by a qualified engineer at a later date.
INDICATION ORIENTATION	MPI will only work if the discontinuity lies across the lines of magnetic force - ie. perpendicular (ideally) to the flux direction.

If the lines of force are cut, north and south poles are produced and flux leakage occurs. If the defect lies parallel to the flux direction, leakage may not occur and no indication will show. For this reason, proper MPI should always involve 2 tests with different directions of magnetisation.

**INDUCED CURRENT-
FLOW TECHNIQUE**

A technique of magnetising in which a circulating current is induced in a ring component by the influence of a fluctuating magnetic field which links the component.

INDUCED FLUX, B

This is related to the applied field, H as:
 $B \text{ (Gauss)} = \mu H \text{ (OERSTED)}$, where μ is the permeability of the metal.

INK

This is a suspension of finely divided magnetic oxides in a liquid medium.
The ink is applied to a cleaned surface to be examined in order to reveal magnetic flux leakage fields and to detect any discontinuities.

L

LINES OF FORCE

Theoretical lines within the test piece showing direction of magnetism. Either North Pole to South Pole outside a magnet (completing the South to North Pole circuit inside) or perpendicular to the current inducing the magnetism, in the direction defined by the cork screw rule.

M

MAGNETIC FIELD

The space in the vicinity of an electric current or a permanent magnet throughout which the magnetic flux induced by the current or caused by the magnet can be detected.

MAGNETIC FIELD LEAKAGE	The loss of magnetic field strength due to discontinuities and changes in section in a magnetic circuit. (see indication orientation).
MAGNETIC FIELD STRENGTH	The measured intensity of a magnetic field at a point, usually expressed in oersteds.
MAGNETIC FLOW TECHNIQUE	A technique of magnetisation in which the component or a portion of it closes the magnetic circuit of any electromagnet or permanent magnet.
MAGNETIC POLES	The points in a magnet which are the apparent seat of the external magnetic field. They are the 2 faces (called North and South) of a break in the magnetic flux path where magnetic flux leakage takes place.
MAGNETIC WRITING	Spurious indications arising from random local magnetisation.
MPI	Magnetic Particle Inspection - Non destructive testing technique using magnetism to detect surface breaking discontinuities.
	Underwater system comprises coil, underwater unit, umbilical, surface transformer, surface control unit, fluorescent ink and black light.

P

PERMANENT MAGNET	A section of a material which possesses natural magnetic properties. It is differentiated from electro magnets which are generated by electric current flow through a conductor to create a magnetic field in a perpendicular direction to the current flow. It is a magnetised piece of high retentivity material.
------------------	--

PERMEABILITY (u) The ratio of the magnetic induction (B) to the external magnetic field (H) causing the indication. This is a material property defined as the ease with which materials can be magnetised. A high permeability is associated with easy magnetisation, low retentivity and low coercivity. Low permeability - difficult magnetisation high retentivity and high coercivity.

POWDER Magnetic particles in dry powder form of suitable shape and size for flaw detection purposes.

PRODS Hand-held electrodes attached to wander cables to transmit the magnetising current from the source to the component under examination.

Major disadvantage is if not used correctly they can cause surface burn marks at the point of contact.

R

REFERENCE PIECES Specimens containing controlled artificial defects or natural defects used for checking the efficiency of magnetic particle flaw detection processes. A common type of reference piece is the Burmah-Castrol strip, a thin strip of copper with 4 slivers of iron along its width. The gaps between them give rise to position indications when examined by MPI and laid along the piece under examination.

RESIDUAL MAGNETISM The magnetism remaining in a component when after initial magnetisation the magnetising force is reduced to zero. (See retentivity).

RESIDUAL MAGNETISM TECHNIQUES Techniques where a magnetic force is applied to a test piece then removed before inspection. Can only be used on materials with high retentivity ie. enough residual magnetism to perform MPI. Also can only be used reliably where magnetising force is provided by a DC system or permanent magnet.

RETENTIVITY

After application of a magnetising force an amount of residual magnetism will be left in the material, depending on its permeability. The degree of residual magnetism is called the retentivity. It can be thought of as a measure of a material's ability to act as a permanent magnet.

S

SATURATION

The stage at which any further increase in the magnetic field applied to a magnetised component will fail to show any significant increase in the magnetic flux in the component.

**SURFACE CONTROL
UNIT**

Provides a means of control on the surface, usually in the dive control room, as a failsafe for the protection of the diver.

SURFACE TRANSFORMER

Takes the ship's power via the control unit and provides high current low voltage power for the magnetising current passed via the underwater unit to the coil.

T

**THREADER BAR
TECHNIQUE**

A technique of magnetisation in which a current-carrying bar, cable or tube is passed through a bore or aperture in a component under examination to reveal axial or radial defects. Threading Coil Technique is a development of the above in which a magnetising coil is used instead.

U

UMBILICAL

Insulated cable carrying current from surface transformer to the underwater unit.

UNDERWATER UNIT

Watertight unit with transformers, and connections for the coil, ink applicator and U.V. lamp (black light). It also has an attached container holding the bag of fluorescent ink.

Y

YOKE

A piece of ferro-magnetic material in an electromagnet. The coil wound on it induces a magnetic field through it which allows the yoke to be used like a magnet when current is passed through the coil.

2.3 RADIOGRAPHY

Term

Definition

A

ACTIVITY

The activity of a radio-active substance is given by the number of atoms of the substance which disintegrate in a given time. This is measured in Curies (C). One Curie represents 3.7×10^{10} disintegration per second.

ALPHA RADIATION

A flux of positively charged particles of helium nuclei. The atom emitting alpha radiation reduces its atomic number by 2 and its mass by 4. Alpha radiation has very limited penetration, being absorbed by a thickness of paper. Consequently, alpha radiation plays no part in industrial radiography.

ARTIFICIAL RADIO- ACTIVE SOURCE

Source which emits a lot of gamma radiation suitable for N.D.T. and is available at reasonable cost as a by-product from the atomic power industry.

ATOM

Smallest particle of matter which can enter into chemical reactions. Consists of nucleus, of neutrons and protons, surrounded by electrons.

ATOMIC NUMBER

Number of protons in nucleus of atom. It identifies the element.

ATOMIC WEIGHT

Generally accepted as the total number of protons and neutrons in the nucleus. Some elements have many isotopes so their weight is taken as the proportional average of all isotopes of the element

B

BARIUM CONCRETE

Concrete containing a high proportion of barium compounds used for radiation protection.

BEQUEREL (Bq) SI unit of radioactivity. 1 Bq represents one disintegration per second.

BETA RADIATION A flux of negatively charged particles. The particles are electrons, the result of such radiation is an increase in the atomic number by one and the atomic weight remains the same. Beta radiation has limited penetration, being absorbed by a modest thickness of Aluminium. Consequently, like alpha radiation, it plays no part in industrial radiography.

BLOCKING MEDIUM Material used to surround or fill cavities' in an object to reduce the effect of scattered radiations on the film.

C

COLLIMATION The limiting of a beam of radiation to a near parallel form, using diaphragms of absorbing material.

CONTAINMENT VESSEL Receptacle to retain radioactive material during transit even if any vessels within it break.

CONTAMINATION Unwanted radioactive material deposited on surfaces.

CRAWLER MACHINES Machines developed specially for radiography of pipelines, may use either X-Rays or Gamma Rays. The source or X-Ray machine is mounted on a carriage which crawls inside the pipeline. It may be battery or cable powered or even powered by an internal combustion engine. The crawler is positioned under a weld using a detector mounted on the crawler. The film is then placed around the outside of the weld and the radiograph made. Crawlers have been widely used in subsea pipeline laying from barges in the North Sea and world wide.

CURIE (Ci) Unit of radioactivity defined as 3.7×10^{10} disintegrations per second. One Curie = 3.7×10^{10} Bequerels.

D

DEFECTS See weld defects.

DETECTORS Method of detecting radiation. Can be gas filled
- Ionisation Counter,
Proportional Counter, Geiger Counter
or
solid state - spectrometers, contamination monitors,
photographic film or personal dosimeters.

DOSAGE Amount of radioactivity absorbed by a material.
Measured in Rads.

DOSEMETER Instrument for measuring quantities of radiation.

DOSE RATE A measure of the presence of ionising radiations normally indicating the rate at which energy is being deposited in a medium. (Measured in Rads/hr or Rem/hr).

E

EXPOSURE CONTAINER Provides shielding for a sealed source and allows a limited useful beam when source is exposed for carrying out industrial radiography.

F

FILM

Photographic and X-Ray sensitive film are very similar in general make up, with X-Ray film being coated on both sides.

There are essentially four layers.

Supercoat: gelatine protective layer.

Emulsion: light or radiation sensitive layer.

Subbing layer: ensures good adhesion of emulsion to the base.

Base: supports the delicate emulsion and other layers. Consists generally of a thin sheet of cellulose tri-acetate, a tough but transparent material.

FILM BADGE

Monitoring device for the dosage of radiation received by the wearer. The badge consists of a strip of film held in a plastic container which is fitted with filters so that the range and type of radiation received on the film can be determined. The amount of film blackening indicates the dose received by the wearer. A disadvantage of this system is that a 24 hour turnaround is required for processing of the film.

Hence it only relates the dose already absorbed by the wearer. However, action may then be taken if a high dose has been received, with further tests made as necessary.

FISSILE MATERIAL

Material capable of undergoing nuclear fission, where atoms are split into two with the release of ionising radiation.

FLASH RADIOGRAPHY

Radiography in which the exposure time is very short for the purpose of examining transient effects.

G

GAMMA RADIATION

This is non-particulate radiation, carrying no electrical charge. It is electro-magnetic in nature, having wavelengths in order of 10^{-10} m.

This radiation has good penetration, and along with x-rays is used for industrial radiography.

GEIGER-MULLER COUNTER

Method of detecting and measuring the amount of radiation.

GRAY (GY)

SI unit of absorbed dose which is a measure of the amount of radiation energy deposited in any medium, equivalent to one joule per kilogram.

H

HALF LIFE

The period of time in which the intensity of the radiation emitted from an isotope will fall to one half of its initial level. Each radioactive element has its own characteristic half life. The half life may range from minutes to many years.

HALF VALUE LAYER

This is a definition of the energy of Gamma radiation.

It is defined as the thickness of material required to reduce the radiation intensity by one half. This is generally expressed in cm, each isotope having its own characteristic half value layer.

I

IMAGE QUALITY INDICATOR

Device comprising series of elements of graded Thickness of same material as that under examination which enables a measure of the quality of the image to be obtained.

**INTENSIFYING
SCREENS**

The degree of photographic effect of incident radiation is dependent upon the amount of absorption by the film emulsion. In practice only 1% may be absorbed by the emulsion. To improve this, intensifying screens are sandwiched around the film, these either fluoresce or emit electrons and produce an extra photographic effect upon the film emulsion. Close contact must be maintained between the film and the screens, hence they are always used inside the film cassette.

ISOTOPE

The isotopes of any given element possess the same atomic number, but different atomic weight (mass) numbers. i.e. different numbers of neutrons in the nucleus. An element is defined by its number of protons and its weight is taken as the average of all its isotopes. Not all isotopes of a radioactive element have to be radioactive.

ISOTOPE CAPSULE

Radiation source surrounded by a sheath, usually of metal. The sheath prevents the dispersal of radiation during severe accident conditions.

L

LATENT IMAGE

Latent, meaning hidden, used to indicate the image produced in the film emulsion, but is invisible until the film is chemically developed, hence revealing the image.

**LLS MATERIAL (LOW
LEVEL SOLID)**

Material with a low level of activity which is solid or is uniformly distributed in a binding agent such as consolidated wastes or contaminated material.

**LSA MATERIAL (LOW
SPECIFIC ACTIVITY)**

Material with radioactive elements in solution which gives off a low level of radiation per unit volume. A bit like dilution of radioactive materials.

M

- MASS NUMBER** The net number of protons and neutrons in the nucleus. Identifies the isotope.
- MOVING BEAM RADIOGRAPHY** In which the specimen is scanned by a collimated radiation beam.

P

- PENUMBRA** (a) Geometric unsharpness on radiograph caused by incorrect geometry of set up and too large a source.
(b) Blurring at the edges of an image caused by large sources.
- PENETRATION** Is the distance through the subject material that radiation can travel before being fully absorbed.

Q

- QUALITY FACTOR** Numerical value assigned to a radiation depending on the type and energy of the radiation. It compares the ability of the particular radiation with that of 200 keV x-rays to cause biological damage.

R

- RAD** Unit of absorbed dose. A measure of the energy deposition in a medium by all types of incident ionising radiation. One Rad is defined as an energy deposition of 10^{-2} joules per kilogram. 100 rads = 1 gray.
- RADIATION** Streams of high speed particles or electromagnetic rays emitted by atoms. Unstable nuclei emit radiations of three main types.

ALPHA - radiation
BETA - radiation
GAMMA - radiation

However, under certain circumstances neutrons and x-rays can also be emitted during the decay process.

**RADIOACTIVE
MATERIAL**

A material which has a specific activity greater than 0.002 microcurie per gram.

RADIOACTIVITY

Process of radioactive decay in which unstable atoms undergo spontaneous transformation into more stable product atoms by emitting charged particles and/or electromagnetic radiation.

RADIOGRAPH

This is the developed film, in effect a negative image, with defects and any differences in the thickness of material showing as light or dark sections of the image.

REM

This is a biological dose unit, taking into account the capacity of different radiations to cause biological damage as compared to 200 KEV, x-rays. It is therefore a unit of absorbed dose equivalent which is obtained by multiplying the absorbed dose (RAD) by the particular quality factor.

RESOLUTION

This is the ability of the technique to give separate and distinct indications of discontinuities. In practice, this is a combination of size and difference in thickness caused by a defect.

It may be that the technique can distinguish between radiation levels from the radiograph corresponding to a 2% difference in thickness. Consequently a cavity in the specimen with a diameter equal to or greater than 2% of the specimen thickness will be detected, smaller cavities will go undetected.

ROENTGEN Unit of exposure expressing the amount of ionisation caused in air by X or Gamma radiation. One Roentgen corresponds to the production of ions (+ or -) carrying a charge of 2.58×10^{-4} coulombs per kilogram of air.

S

SCATTER When a beam of X or Gamma rays passes through an object, part of the radiation is scattered in all directions by the atoms forming the object. The scatter results in an overall fogging, reduces contrast and hence spoils the image sharpness. The degree of scatter increases with the thickness of the object being radiographed. Scattered radiation is generally softer than that from which it is derived. Can be intercepted using a metallic filter before reaching the film.

SHIELDING A means of reducing the doses received by persons in proximity to a source of ionising radiations. It can be achieved by:

- a) Placing absorbing medium around the source
- b) Restricting access to the source
- c) Limiting the time people are exposed to the source.

SOURCE The isotope emitting radiation (or x-ray machine) This will have a known output and will be shielded to the required legal standards of radiological protection.

T

TRANSPORT CONTAINER Package or containment vessel used to transport radioactive material.

TRANSPORT INDEX

Number expressing the maximum radiation dose rate in millirem per hour at one metre from the external surface of the package.

W

WELD DEFECTS

Porosity: revealed as circular spots of higher density than background in the radiograph.

Inclusion: as per porosity in the radiographs, but produce angular spots.

Incomplete Root Penetration: shown on the the radiograph as a dark continuous or intermittent band parallel to the length of the weld.

Lack of Root Fusion: on the radiograph shows up as fine, straight, dark lines along or near the weld image centre.

Cracks: show as fine, dark, tortuous or wavy lines, which are sharp when the beam of x-rays passes along the plane of the crack, but are more diffuse and less dense as the angle between the beam and the crack increases.

X

X-RAYS

Electro magnetic radiation, similar to gamma rays, but of a longer wavelength.

Produced by bombarding eg. Tungsten with high velocity electrons in x-ray machines, X-Rays are widely used in both medical and industrial radiography. They have an advantage over gamma radiations in that they are produced at will, when the machine is activated.

They have a lower penetration than do gamma rays, however, the choice is always application dependent.

X-RAY FILMS

X-Ray film is basically the same as standard photographic film, with a couple of exceptions. It has emulsion at both sides of the support material. This reduces exposure time. Secondly the emulsion has its sensitivity tailored to x-rays and other related radiations.

X-RAY MACHINE

Produces x-rays, by bombarding an anode with high velocity electrons. The potential difference between the anode and the cathode determines the penetration of the x-rays, a higher PD produces shorter wavelength x-rays which have greater penetration.

The anode is generally of Tungsten, partly because of the high atomic number and partly because of its high melting point. During operation of the x-ray machine, the anode becomes very hot, hence cooling oil is used to dissipate this heat through a casting. The anode target of Tungsten, is mounted on a copper support also to aid cooling.

2.4 ULTRASONICS

<u>Term</u>	<u>Definition</u>
	A
ABSORPTION	Component of attenuation resultant from ultrasonic energy being converted to heat by material through which it travels.
ACOUSTICAL COUPLING	The condition of incidence, whereby ultrasound is passed from the probe onto the material under examination. It is produced by interposing a coupling medium such as oil between the probe and the surface of the workpiece.
ACOUSTIC SHADOW	Region of body being tested that sound is prevented from reaching, by body geometry or discontinuities.
AMPLITUDE	The height of an echo on the crt. screen: the magnitude of the input voltage impulse producing the echo signal.
ANGLE OF THE BEAM SPREAD	The solid angle which contains the main lobe of an ultrasound beam in the far field.
ANGLE OF INCIDENCE	The angle between the axis of the ultrasonic beam and the normal to a surface on which it impinges, as it travels to that surface.
ANGLE OF REFLECTION	The angle between the axis of the ultrasonic beam and the normal to a reflecting surface, as it travels away from that surface in the same medium. Numerically equal to the angle of incidence.

ANGLE OF REFRACTION The angle between the axis of the ultrasonic beam and the normal to an interface between two media as it travels away from the interface into the second medium. The complement of the angle of refraction is the angle of Dip.

ANGLE PROBE A probe from which the beam propagates at any angle of refraction between 0° and 90° . Two kinds are in use:

Angle greater than 0° less than 20° (compressed waves)

Angle greater than 33° less than 90° (shear waves)

The angles quoted are for steel. Compressional wave angle probes are rarely needed for weld testing. N.B. The angle quoted is the angle the refracted wave makes with the normal in the steel.

A-SCOPE PRESENTATION A form of cathode ray tube (crt) display in which signal strength (echo height) is represented by displacement in the vertical direction (Y axis) and time, or distance travelled, is represented by displacement along the time base (X axis).

ATTENUATION The loss of intensity suffered by ultrasonic waves as they pass through the material under test. This loss is almost entirely due to scattering. (see Scattering, Absorption).

ATTITUDE The lie of a flaw or other reflector relative to the oncoming ultrasonic wave. An attitude is said to be favourable or unfavourable for strong reflection. (See Orientation).

AUDIO FREQUENCY Any frequency of vibration within the range 20 to 20,000 Hz and therefore in the audible or sonic range.

AVG DIAGRAM

A family of distance-amplitude correction curves based on accoustical theory and first formalised by J. Krautkramer in 1958.

These initials have in recent times been replaced in the UK by the English equivalents, DGS (distance-gain-size). (See DGS system).

AXIS

A line which divides a figure symmetrically. The straight line by revolution about which a plane figure is conceived as generating a solid ("solid of revolution").

B

BACKWALL/BOTTOM

Energy pulse reflected from boundary of body ECHO directly opposite surface on which probe rests and returned to probe by the shortest path. (Compression waves).

N.B. with shear waves where the backwall echo does not return to the probe is called the boundary echo.

BEAM AXIS

The locus or trace of points of maximum intensity in the far field of the ultrasonic beam, and its geometrical extension into the near field. (The near field does not show a continuous maximum intensity along this line).

BEAM PROFILE

A profile plotted from observation of the relative probe positions at which the response from an appropriate target falls to a predetermined fraction of that recorded when the target lies on the axis of the beam.

Ideally, such profiles should be plotted for different longitudinal sections of the beam and at more than one level of amplifier gain. (See Effective Beam Profile).

BEAM SPREAD The divergence of the main lobe of an ultrasonic beam in the far field. Rather like light spreads from a torch.

B-SCOPE PRESENTATION A form of cathode ray tube display, in rectangular co-ordinates, in which the travel time of an ultrasonic pulse is represented as a displacement long one axis, the probe movement (generally rectilinear) is represented as a displacement along the other axis. In the display, reflected pulses are shown as bright marks on a dark background, or vice versa.

C

CALIBRATION BLOCK A piece of material of specified composition, heat treatment, geometric form, and surface finish, by means of which ultrasonic equipment can be assessed and calibrated for the examination of material of the same general composition.

COMPRESSIONAL WAVE A form of wave motion in which the particle displacement (particle orbit) is parallel to the direction of propagation, the displacement itself consisting of alternative cycles of compression and dilation. Also referred to as a longitudinal wave.

CORNER EFFECT The reflection of ultrasonic waves back to their point of origin, or very close to it, after impinging successively on two surfaces at right angles to each other.

With 60° probes corner-reflection is accompanied by appreciable attenuation.

COUPLANT
(COUPLING MEDIUM)
(COUPLING FILM) A liquid, grease, paste or pliable solid interposed between the probe and the surface of the workpiece to assist the passage of ultrasonic waves between them.

CRITICAL ANGLE

The maximum angle of incidence at an interface between 2 dissimilar materials which will permit the existence of a refracted wave of given mode and finite amplitude.

This formal definition can be re-stated thus: a critical angle is an angle of incidence at an interface between 2 dissimilar materials beyond which a new mode appears in the refracted beam and the existing one vanishes.

Example: for Perspex on steel: angle of incidence 27 1/2 degrees, compressional wave mode vanishes and is replaced by shear.

Transition from shear waves to surface waves, angle of incidence 58° approximately (depending on characteristics of Perspex). (See Angle of incidence: Interface).

CROSS NOISE (CROSS TALK)

Acoustical interference produced in the detecting element of a two-probe system, or of a double-crystal probe, by surface wave energy generated by the transmitting element (See Rayleigh wave).

CRYSTAL (PROBE CRYSTAL)

A piezo-electric element in the form of a wafer cut from a single (natural) crystal, e.g. quartz, or from a piece of polycrystalline (synthetic) material, e.g. barium titanate, used for the generation and/or detection of ultrasonic waves. (See Piezo-electric).

C-SCOPE PRESENTATION

The line-by-line presentation of flaw data obtained by scanning the major surface of the material line-by-line (non-intersecting lines) so the discontinuities are shown in terms of probe position at the moment of detection. The presentation may be on a cathode ray tube screen or recorded on paper or film, i.e. a two-dimensional presentation.

CYCLE

Any series of changes imposed upon a system the final stage of which returns it to its original state e.g. the complete excursion of a displaced particle from its mean or "rest" position, through a maximum in one sense, back through the mean to a maximum in the opposite sense, and back once more to rest, constitutes one cycle.

The wave frequency of a train of waves is measured in cycles per second. (See Hertz).

D**DAMPING**

Literally "Quieting". Decrease in the amplitude of a wave motion or an oscillation with time.

(Spec) Probe crystals are damped by means of a sound-absorbent backing to prevent them from "ringing" for too long when energised, and thus to assist in promoting good signal resolution.

DEAD ZONE

A region immediately beneath the entry surface from which no direct echoes from discontinuities can be either detected or identified, due to the characteristics of the equipment, e.g. persistent probe noise, and/or those of the material itself.

DECAY TECHNIQUE

A method of using ultrasonic waves to assess the quality of a material or a bond by studying the amplitudes of successive echoes.

DECIBEL (dB)

A logarithmic unit originally applied to the comparison of levels of electrical power, and now also used to compare sound pressures (echo heights).

Two echo signals h' and h'' are said to differ by n dB when

$$n = 20 \log_{10} h'/h''$$

DECREMENT	The ratio of the peak values of the amplitudes of two successive cycles of a lightly damped train (cf. "logarithmic decrement").
DGS SYSTEM	A family of distance-amplitude curves originally computed for the case of compressional waves incident upon small smooth, planar (disc) reflectors, and relating echo height to the size of the disc, its distance from the probe, and the intensity of the back echo. The curves have since been adapted for use with flat-bottomed-hole calibration blocks and shear wave probes.
DIFFUSE REFLECTION	Refection of an ultrasonic wave from a rough surface in a manner such that the reflected energy is detectable over a range of angles on either side of the theoretical angle of (specular) reflection, i.e. reflection in a non-specular manner.
DISTANCE AMPLITUDE CORRECTION CURVE	<p>(a) A curve constructed from the responses from a master target at several different ranges and subsequently plotted on the crt screen (in wax pencil) to facilitate judgement of the significance of flaw echoes.</p> <p>The target may take the form of a real flaw or of its calibrated equivalent, e.g. a drill hole, in a reference block.</p> <p>(b) A curve plotted specifically for a flat-bottomed-hole and engraved on a transparent plastic sheet for attachment to the crt screen. (See DGS system).</p>
DOUBLE-BOUNCE TECHNIQUE	An alternative name for the triple-traverse technique in which the probe, placed at $1\frac{1}{2}$ - skip distance, directs the beam into the weld after bouncing it off the far surface (bottom) and the top surface in succession.

The number of bounces is always one less than the number of traverses.

**DOUBLE CRYSTAL
PROBE**

A probe employing 2 separate crystals in a single housing, one of which acts as a transmitter and the other as a detector, alternately. (Also known as Twin Crystal Probe).

The crystal assemblies are separated by an accoustical barrier (usually cork) in order to prevent cross noise.

**DOUBLE PROBE
TECHNIQUE**

A technique involving the use of one probe for transmission of ultrasonic energy and a second probe for its detection. Where the second probe is on the opposite side of the test piece this technique is known as straddle scan.

E

**EFFECTIVE BEAM
PROFILE**

The effective beam form may be defined as the envelope of the beam outside which at any given instrument control setting the signal from the target will have diminished by 90% in amplitude or 20 dB. Knowledge of the effective beam form and its variation with overall sensitivity is of more value than knowledge of the theoretical polar diagram.

Apart from the effect of unforeseeable test conditions such as poor coupling, e.g. rough surfaces, the distance from the beam axis at which the signal falls off depends upon the range of frequencies present in the signal and upon the nature of target, i.e. round or flat, large or small.

Successful flaw location and size estimation are both vitally dependent upon the tester's knowledge of the variation of beam profile for characteristic control settings.

EXPANDED TIME
BASE SWEEP
(SCALE EXPANSION)

A crt presentation incorporating a variable speed of time base spot sweep which permits expansion (or contraction) of the screen display in order to adjust the range setting or to accommodate a changeover of wave velocity e.g. a changeover from a compressional wave probe to a shear wave probe. Scale expansion is as essential to calibration as trace delay.

F

FAR FIELD

The main lobe of an ultrasonic beam where the intensity of the sound field is inversely proportional to the square of the distance from the transmitter. Sometimes referred to as the "far zone" and the "Fraunhofer" region.

FLAW ECHO

The pulse of ultrasonic energy reflected by an imperfection in any material or body.

FLAW LOCATION SLIDE

A two part transparent scale consisting of a graduated stock showing probe stand-off distances and a transparent cursor carrying a profile of the weld preparation (usually enlarged). There are variants of this design, but all are equally needed to promote quick and accurate flaw location as an essential part of the test procedure.

FOCUSING PROBE

A probe containing either a mosaic of crystals on a concave backing or an acoustic lens made of plastic material and functioning by virtue of Snell's Law. Focusing probes have been used with success in flaw size estimation but the technique (immersion testing) is not suitable for weld examination.

Some degree of focusing is obtainable in double crystal probes by bevelling the Perspex blocks on which the crystals rest to give an angle of refraction in the workpiece of about $3\frac{1}{2}^{\circ}$ and thus shortening the dead zone.

FREQUENCY

In wave motion, the number of cycles per second. Numerically equal to the velocity of propagation divided by the wavelength.

G

GAIN CONTROL

An instrument control which enables the degree of amplification of incoming signals to be regulated. Two such controls are usually fitted.

(a) "Gain"; uncalibrated i.e. the control usually bears no graduations except a mark indicating the "off" position.

(b) "Auxilliary gain" or "Attenuator"; consisting of two concentric dials, the outer dial graduated from 0-80 dB in steps of 10 dB and the inner one from 0-10dB in steps of 2 dB.

Sometimes the graduations show the maximum reading at the starting position (nominally '0'). The recording of gain adjustments should therefore always be algebraic in order to avoid confusion.

GHOST ECHO

Indication arising from wrong combination of pulse repetition frequency and time base frequency.

GRASS

A background of unwanted signals due either to the gain setting, the characteristics of the test equipment, or of the material under examination, and randomly distributed along the time base, against which flaw signals have to be identified. (See Suppression).

H

HERTZ (Hz) The name assigned in the international code of metric units (or so-called SI units) to the unit of frequency, e.g. a wave frequency of 20,000 c/sec is spoken as 20 kilo Hertz and written 20 kHz. Two megacycles per second is written 2 MHz.

The formal definition of this unit is: "the frequency of a periodic phenomenon of which the periodic time is one second".

The unit is named after the mathematical physicist. Heinrich Hertz (1857-94).

**HORIZONTAL
REFERENCE LINE**

A horizontal line near the centre of the ultrasonic test instrument scope to which all echoes are adjusted for dB reading.

I

INDICATION

The signal displayed on the oscilloscope signifying the presence of a sound wave reflector in the part being tested.

INDICATION LEVEL

The calibrated gain or attenuation control reading obtained for a reference line height indication from a discontinuity.

INDICATION RATING

The decibel reading in relation to the zero reference level after having been corrected for sound attenuation.

**INITIAL PULSE
INDICATION**

(Transmitter pulse indication) - (Main Bang, USA).

A signal on the crt screen marking the instant at which a voltage impulse is applied to the transmitting crystal. Its rising edge is frequently invisible owing to time lag in the probe shoe and the consequent necessity to ensure coincidence between the time base zero and the instant at which the transmitter pulse actually enters the material under test.

INTERFACE

Transition face between two materials of different density (or acoustic impedance) in acoustic contact.

L

LEG

The path the shear wave travels in a straight line before being reflected by the surface of material being tested. Equals one traverse of the material.

LINEARITY

A property of the relationship between two varying quantities so that a change in the value of one is accompanied by a directly proportional change in the other. The graph representing the relationship (plotted on ordinary squared paper) is then a straight line.

Thus, in an ideal screen display there would be an unchanging linear relationship between signal voltage and amplifier output, i.e. echo height.

The same applies to the connection between the periodic rise and fall of sweep voltage and the speed of travel of the time base spot across the screen.

LONGITUDINAL WAVE

The name originally given by mathematicians to the type of particle displacement which engineers recognise more readily as a compressional wave. (See Compressional Wave).

M

MAXIMISING

Manipulation of the probe (transverse and/or rotation) to ensure that the signal displayed is the strongest obtainable from the reflector concerned.

Especially important with shear wave probes when calibrating or range finding. (See Directional sensitivity: Radiation pattern).

MODE TRANSFORMATION

Process by which a wave of given mode of propagation (shear/comp) is caused to change to the other mode, e.g. refraction or reflection off rough surface.

N

NEAR FIELD

'The region in an ultrasonic beam which is subject to variations of intensity due to diffraction effects. It extends from the source of radiation to a point just short of the far field. (Sometimes referred to as "Fresnel region" or "near zone")'.

Diffraction is a particular example of wave interference and is common to all wave motion. It was the subject of a special study by A.J. Fresnel (1788-1827).

Flaw detection in the near zone should be avoided unless the characteristics of the probe used are accurately known.

Double crystal probes reduce the interference effects in the near field.

NORMAL PROBE

Straight Beam Probe (USA). - 'A probe from which waves propagate at 90 degrees to its contact surface'.

In normal testing practice this implies a compressional wave probe. (See Zero angle probe).

O

ORIENTATION

Flaw orientation should be considered at the procedure development stage. Cracks and other planar defects are very difficult to detect if orientated such that the beam axis is parallel to the plane of the defect. Ultrasonic inspection should always be carried out with more than one angle of incidence to maximise the chances of the beam hitting the faces of planar defects which give a better reflection than the edges.

P

PENETRATION

The distance a wave will travel through a substance before being fully absorbed. The useful penetration is the distance from which a pulse can be bounced off an interface and still give a useable indication.

PIEZO-ELECTRIC EFFECT

A property of certain natural crystals which, when subjected to mechanical strain, e.g. pressure, develop electric charges of opposite sign on opposing faces. Discovered by P. and J. Curie in 1881.

It is now possible to produce this effect in synthetic crystals prepared from suitable processed mineral powders.

Conversely, the application of an electrical potential will induce mechanical strain, e.g. compression or dilation, between opposing faces. This so-called inverse effect is utilised when a crystal is required to transmit ultrasonic waves, and the direct effect when it is required to detect them, i.e. electrical pulses cause crystal to vibrate giving sound and sound received vibrates the crystal giving electrical pulses.

PROBE INDEX

The point on a probe through which the emergent beam axis passes.

PROBE SHOE

A piece of solid material (usually Perspex) interposed between the probe crystal and the material under examination, either to improve acoustical contact or, by virtue of its shape, to shorten the dead zone, e.g. twin-crystal probes, or refract the beam, e.g. shear wave probes.

PULSE

Wave Packet - A damped wave train employed in the pulse echo technique, so that the amplitude falls to one-tenth of its peak value in not more than five cycles.

**PULSE-ECHO
TECHNIQUE**

A technique in which the presence of a discontinuity in a material is indicated by the reflection of pulses from it.

**PULSE REPETITION
FREQUENCY**

The number of pulses transmitted per second.
(Abbreviation: p.r.f.).

R

RAYLEIGH WAVE

Surface Wave (After Lord Rayleigh, Mathematical Physicist 1842-1919) - 'A particular type of surface wave which propagates on the surface of a body with effective penetration of less than a wavelength'.

Unwanted waves may be generated at the entry surface by shear wave probes of 70 degrees angle or over. They are also responsible for cross noise.

REFERENCE BLOCK

Technique Block - 'An aid to interpretation in the form of a testpiece of the same material, significant dimensions and shape as a particular object under examination, but not necessarily containing natural or artificial defects'.

The foregoing is a general definition. In weld testing, such a block usually contains natural or artificial targets either for the purpose of setting sensitivity levels (in which case the targets should, ideally, be equivalent in reflectivity to specific types of flaws) or for use as an aid to interpretation, e.g. a section of a T fillet weld. (See Sensitivity level).

REFERENCE LEVEL

The decibel reading obtained for a horizontal reference line height indication from a reference reflector.

REFERENCE REFLECTOR

The reflector of known geometry contained in the IIW reference block or other approved blocks.

REFLECTION

Reversal of a wave direction where a wave bounces off an interface it cannot cross, e.g. metal/air.

REFRACTION

The change in direction of travel of a wave caused by crossing the interface of two materials with different densities, i.e. different sonic velocities.

RESOLUTION

'The ability of an ultrasonic flaw detection system to give separate indication of discontinuities having nearly the same range and/or lateral position with respect to the beam axis'.

Weld examination is concerned more with differences of range (depth resolution) than with those of lateral position, i.e. angular resolution.

RESONANCE TECHNIQUE A technique which involves varying the frequency of ultrasonic waves to excite a maximum amplitude of vibration in a body or part of a body generally for the purpose of determining thickness from one side only.

S

SCANNING LEVEL xDb above base.

SCATTER Loss of energy in the beam due to reflection, etc. in different directions from rough surfaces and discontinuities. It is the greatest contributor to attenuation.

SENSITIVITY LEVEL A gain setting chosen after an exploratory scan to assess the testing conditions and recorded by reference to an appropriate test block. (See Reference block).

SHEAR WAVE A form of wave motion possible only in solids, in which the particle displacement (orbit) is at right angles to the direction of propagation. Also referred to as a transverse wave.

SKIPPING Where shear waves enter test piece at an angle and are allowed to bounce off the backwall before reaching discontinuities. Very useful where access is restricted.

Full skip is where the bounce is allowed but half skip is where the beam is just traversed directly into the test area.

SHADOW TECHNIQUE	Double probe technique where discontinuities are revealed by the shadows they produce.
STRADDLE SCAN	See Double probe technique.
SOUND PATH DISTANCE	The distance between the search unit test material interface and the reflector as measured along the centre line of the sound beam.
STAND-OFF	A distance measured along the surface of the workpiece from the centre line of the weld joint (or other datum) to the shear wave probe index, initially to indicate the half and full skip positions and , at a later stage, to provide a reference point for flaw location using the flaw location slide.
SUPPRESSION	(Grass Cutting, Reject) - The reduction of noise by suppression of all signals below a predetermined amplitude. Many flaw detectors are fitted with a control for this purpose but in some designs suppression is a permanent feature and thus beyond the control of the tester. This is a matter for consideration when choosing equipment for a given purpose.
T	
TIMEBASE	Horizontal trace, on screen of cathode ray tube, of timed pulse allowing X-axis distance to be read as proportional to time.
TOTAL ATTENUATION	Complete loss of energy in a sound pulse over a distance travelled due to combined effects of absorption, scatter and beam spread.
TOTAL REFLECTION	Where all energy in a pulse is reflected from an interface due to incident angle being higher than the critical angle at that interface.

TRANSDUCER Device which converts electrical pulses to mechanical movement or vice versa or both. See Piezo-Electric Effect.

TRANSMITTER PULSE INDICATION See Initial Pulse Indication.

TRANSVERSE WAVE See Shear Wave.

TWIN CRYSTAL PROBE See Double Crystal Probe.

U

ULTRASONIC PROBE Small block encapsulating a piezo-electric crystal from which sound pulses are emitted. Inside the casing the crystal sits in a damping medium surrounded by an insulating layer which absorbs spurious signals. The crystal is set on the probe shoe (usually perspex) and is connected to the cathode ray tube controls via a co-axial cable out the back of the probe.

The crystal is set on the shoe in such an orientation as to allow a desired angle of propagation of the wave through the test piece (common 0 degrees, 45, 60, 70, 80 degrees), i.e. 45 degrees shear probe emits waves which result in shear waves travelling at 45 degrees from the normal through the steel.

ULTRASONIC FREQUENCY Any frequency of vibration beyond the upper limit of audibility of the human ear, generally considered to be greater than 20 kHz (in the young).

V

VELOCITY Speed which sound wave is propagated. This varies from material to material due to different densities. Each mode of propagation also has a different velocity in any one material, e.g. in steel, compression waves travel at anywhere between 5700-6100 m/s depending on steel type and shear waves at 3050-3250 m/s.

W

WAVELENGTH

The distance, measured along the line of propagation, between two wave surfaces in which the phase differs by one complete period.

Usually illustrated in textbooks as the distance between identical crests in two successive waves.

Numerically, the wavelength is equal to the velocity of propagation divided by the wave frequency.

WETTING AGENT

Substance added to a couplant to decrease its surface tension.

Z

ZERO DEGREE PROBE

Probe where sound (usually compression) is caused to enter a material normal to its surface. Commonly called a comp. probe.

2.5 PHOTOGRAPHY

Term

Definition

A

ABSORPTION

Taking light energy and transforming it into heat. Natural light is absorbed by water and its suspended particles dependent on particle density, salt solution, depth of travel and wavelength. In seawater the red end of the spectrum is lost at shallow depths but blue light can travel to significant depth. Artificial light, therefore is needed for most underwater work.

ANGLE OF VIEW/ ACCEPTANCE ANGLE

An indication of the area of a subject which can be photographed by a given lens.

APERTURE/APERTURE CONTROL

Regulates the intensity of light admitted to the film by the 'opening up' or 'closing down' of an iris in the lens. Typical aperture settings are marked as :f/1.8, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, and f/22.

A smaller f' stop number means a larger opening. Each successive f'stop admits half the light to the film as its predecessor.

ASA FILM SPEED

System of rating the speed of film by the American Standards Association. Higher ASA number indicates a more sensitive or 'faster' film and vice versa.

Typical ASA values are: 25, 50, 64, 100, 200, 400 and 1000.

Slow films: ASA 25-64
Medium films: ASA 100-200
Fast Films ASA 400-1000

B

BLACK AND WHITE FILM

Film which is used to produce the image in black and white. This is more suitable than colour film in the following situations: when very high definition is required, when colour correction is impossible due to light filtration in excessive stand-off distances or light source colour bias and when a high latitude is required due to uncertain exposure.

BRACKETING

Taking extra shots on either side of pre-determined aperture setting (i.e. one f'stop below and one above). Increases chances of correct exposure with the advantage that wasted film is cheaper than another dive to get a correct exposure.

C

CAMERA

A device used to reproduce an image by focusing light in a controlled manner onto a photosensitive surface.

CAMERA 35MM FORMAT

This provides a frame 24 mm x 36 mm in which a wide range of standard film cassettes are available (film speed, colour, black and white, bulk film lengths). These 35 mm systems are relatively inexpensive, small (allowing access to restrictive areas) produce sufficient quality for most photographic recording needs and are easily viewed as positive transparencies by slide projector.

CAMERA 70 MM FORMAT

This provides a frame of 60 mm x 60 mm. This is approximately four times the area of the 35 mm format. Consequently, a much higher quality photograph is obtained which may be required in some detailed inspection applications. The drawbacks to the 70mm format are: few types of film available, more complicated, expensive, bulky, need careful handling and transparencies cannot be readily viewed by projector if required.

CASSETTE A light, tight container for 35 mm film.

CLOSE UP LENS A lens used for close focusing.

CLOSE UP PHOTOGRAPHY The technique employed in close visual work. This involves short stand-off distances and close up lenses, and allows detail study to be made. Very common offshore for weld photomosaics and photographs of localised pitting etc.

COLOUR FILM This is specified for nearly all still photography underwater. Colour photographs are preferred in most situations because more information may be obtained from them. There are 2 drawbacks to colour film use. These are narrow latitude and the precision required in processing. Latitude is the films tolerance to over and under-exposure. Often a skilled photographic technician is required for on-site processing.

COLOUR NEGATIVE FILM Film which is used to produce the colours of the subject after developing and printing on photographic paper.

COLOUR REVERSAL FILM/COLOUR POSITIVE FILM Film that produces direct positive by reversing the negative image during processing. Produces slides which can be viewed immediately after processing, thus cutting down waiting time for results of important work.

CORRECTION FILTER Filters used to change colours and make them suitable for the colour response of the film. Filters are fitted on the end of the lens.

D

DATA-BACK/
DATA CHAMBER An attachment to the back of the camera providing an identifying/dated imprint on the exposed film via small light emitting diodes, (also see 'IVIS').

DEFINITION	Sharpness of the recorded image. It is the combination of image resolution (the fineness of detail) and contrast (how clearly the details are shown).
DEPTH OF FIELD	The distance from a point in front of the subject to a point behind that appears to the eye to be in focus, i.e. the zone of acceptance sharpness. The higher the F Stop number, the more depth of field and vice versa.
DIFFRACTION	Scattering of light rays around the edge of an opaque substance.
DIN FILM SPEED	Rating of film speeds by the German standards association (Deutsche Industrie Norm) 21 DIN = 100 ASA.
DISTORTION	A change in the shape or proportion of photographic image.
E	
EMULSION	Light sensitive layer used in the production of films and printing papers.
ENLARGEMENT	A print larger than the original negative or transparency.
EXPIRY DATE	Manufacturer's date indicating the working life of films or printing paper.
EXPOSURE	The amount of light that is allowed to reach film or printing paper.
EXPOSURE COUNTER	Device on a camera showing the number of photographs taken.

F

- FAST FILMS** (ASA 400 - 1000) - These have a coarse grain structure which restricts the resolution of fine detail. Since it is more sensitive to light, fast film is used in low light intensity applications. It is ideal for meeting general survey and MPI photographic requirements.
- FILM** A strip of plastic material that is coated on one side with a gelatine surface which contains an emulsion sensitive to light.
- FILM PROCESSING** Usually done offshore by experienced technicians because of the urgent nature of offshore photography. A darkroom, processing equipment and processing kit for colour positive (slide) films, which give quickest finished products, is standard equipment on a D.S.V. (Diving Support Vessel).
- FILM SPEED** A numerical representation of film sensitivity to light. A more sensitive or 'faster' film requires less light for exposure but produces a 'grainy' image. A less sensitive film (slower) produces a sharper image (fine grain), but requires more light for the same exposure.
- FILTER** A material that absorbs certain portions of incident light and transmits the remainder.
- FLARE** Scattered light produced by reflections inside the lens and camera which reduces contrast.
- FLASH ARM** Sturdy articulated arm attachment for holding strobe to camera or housing in position for correct illumination of subject.
- FLASHGUN (ELECTRIC FLASH)** Lighting unit providing a flash or artificial light to enhance illumination of a subject.

FLOODED CAMERA A situation in which water has entered the camera.

F NUMBER OR F STOP (Also see Aperture) Focal length divided by the effective aperture of the lens. It is a numerical expression of the light gathering power of a lens at its different stops.
It is a measurement which indicates the diameter of a lens opening.

FOCAL LENGTH The distance between the optical centre of the lens and the film when the lens gives a sharp image on the film of an object at infinity. The focal length of a lens determines the angle of acceptance, and the scale of the image. Short focal lengths give wider angles but produce smaller subject images on the film. (Used for close up photography or panoramic views). Telephoto lenses have long focal lengths, have narrow acceptance angles but provide magnified subject images for long distance work.

FOCUS (FOCAL PLANE) (FOCAL PLANE SHUTTER) The point where an optical image of the subject is clearly defined on the film or on the mirror through the viewfinder.

FOCUSING The adjustment of the lens to film distance to produce a sharp image to the subject.

G

GUIDE NUMBER A number allocated to the flash gun by the manufacturer to allow calculation of correct aperture for a given subject distance, i.e. a guide to the amount of light produced by the flash. N.B. Underwater guide number differs to that in air so users of dual purpose flashes must remember what medium the manufacturer has quoted for.

I

'IVIS' Trade name for integrated visual imaging system. Links subsea video and stills cameras with data-backs to computer or computer inspection system onboard diving vessel.

IRIS A diaphragm with an adjustable aperture at the focal contact of the lens. See 'F' stop.

L

LATITUDE This is a film's tolerance to over and under-exposure.

LENS Optical device for forming an image of an object on film or photographic paper.

LENS HOOD Shielding to prevent stray light reaching the lens and causing internal reflections.

M

MACRO LENS Lens for close focusing distances which produces high quality results.

MEDIUM FILMS (ASA 100 - 200) Medium films do not have as fine a resolution as slow films but the results are very acceptable for most photographic requirements particularly "stand off" shots.

MONO CAMERA These systems are the most widely used in photographic recording. They range from small, low cost, purpose built water/pressure proof 35mm cameras, e.g. Nikonos to large expensive 70mm cameras in water/pressure proof housings. Intermediate expense cameras include the 35mm SLR Olympus in Scoones housing and the purpose built 35mm Hydroscaan Close Up Camera.

MPI PHOTOGRAPHY

A close-up technique to produce a photographic record of defect indications highlighted by MPI inks. Underwater fluorescent inks are used with a black light (ultra violet).

N

NORMAL LENS

A lens which has a focal length approximately equal to the diagonal distance between 2 corners of the exposed portion of the film.

O

OPTIMUM EXPOSURE

The correct combination of F Stop, shutter speed and film speed rating to give a correctly illuminated, sharp photographic image.

OVEREXPOSURE

Excessive exposure, producing dense, flat negatives and pale transparencies with burnt-out highlights.

P

PARALLAX-

Difference between the image seen in a viewfinder and that recorded by the lens. (e.g. in Pocket Instamatics and 35mm Compact Cameras).

PH

Abbreviation for Photography.

PHOTOGRAPHY

A useful recording method for a number of reasons. A colour photograph gives a permanent high quality (both detail and resolution) visual record of the subject's condition. The results may be presented in transparency (slide) form or as prints.

Still photography is used in both general survey (e.g. node or riser clamp) and close visual inspection (e.g. welds, corrosion, pits etc.) A current development is the increasing use of stereo cameras to provide 3-D images or photogrammetric analysis from which accurate measurements of specific anomalies may be obtained.

PHOTOGRAMMETRY

Science of accurate measurement and analysis from photography, specifically from stereo photographs. Same as stereo photography except all distances are accurately measured and recorded. A scale grid, (also produced on the film) allows 3D measurements to be taken from the 2D films.

The whole system has to be accurately calibrated, usually onshore. For use by specialists only.

PHOTOMOSAIC
TECHNIQUE

A technique in which a sequence of overlapping shots are taken to produce a mosaic of a large subject or circular weld.

PORT

A specially designed transparent domed or plane cover to the subsea camera housing.

PROBE

Attachment to camera or housing with one or more pointers of predetermined length or rectangular frame held at predetermined distance to assist diver with camera direction and stand off distance for close-up photography.

NB: No part of the subject between the prods should be nearer the lens than the prod ends, especially small diameter tubulars when using stereo cameras.

PROCESSING KIT

Standard E6 kit for colour positive film processing comprises developing reels and containers, constant temperature water bath and the following chemicals:- 1st developer, reversal bath, colour developer, conditioner, bleach, fixer and stabiliser. To treat film with each of these separately can be a lengthy process so kits have been developed which incorporate 2 or more of the above processes in each bath reducing the kit to a 3 bath process.

R

REFRACTION The bending of light as it passes from one transparent medium to another of different density, caused by the speed of light changing. The refraction index is a ratio of the velocities in the 2 different densities.

RESOLUTION The ability of the lens and film to record adjacent fine detail. The term indicates the fineness of detail in a photographic image.

S

SHUTTER A device which controls the length of time that the film is exposed to light. Types: Focal Planes, between lens.

SHUTTER SPEED Controls the amount of time that the film is exposed to light. Typical speeds in seconds are 1, 1/2, 1/4, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500 and 1/1000.

As with aperture, each successive setting admits half the light of its predecessor.

SINGLE LENS REFLEX (SLR) CAMERA Camera system which allows viewing the subject through the lens that takes the picture. As a result, what is seen in the viewfinder is recorded on the film and Parallax is avoided. (Also see Parallax). It is done by diverting the light from the lens to film path using a mirror. The mirror is moved to allow the light to reach the film.

SLOW FILM (ASA 25-64) Slow film has a fine grain structure which allows fine detail to be resolved by the film. This high resolution makes slow film ideal for close inspection work. However, it does require high light intensity for optimum performance.

SPORTSFINDER	Rubber rectangular directional aid for attachment to camera to give diver an idea of the picture in view because his mask usually prevents getting close enough to use the viewfinder.
STANDARD LENS	A lens with a focal length similar to the length of the diagonal of the film format. Same as normal lens.
STAND-OFF DISTANCE	Distance between camera and subject. Close-up photography uses a stand-off of 5 cm to 50 cm. "Stand-Off" photography uses larger distances to take in a larger subject area.
STAND-OFF PHOTOGRAPHY	Term given to technique where the camera to subject distance varies between 0.5 and 5 m, although a distance of one meter is most common. It is used for permanent visual records of larger objects or general areas.
STEREO CAMERA	This is a camera that produces 3D pictures. They are not as widely used in underwater inspection programmes as the mono system but they are becoming more popular. They are more complex involving the use of large, single housings or 2 camera housings installed on a jig. Adequate site access, good visibility and correct lighting are essential in stereo photography. It is available in both 35mm and 70 mm formats.
STEREO PHOTOGRAPHY	Provides three dimensional viewing by overlapping a pair of photographs taken of a subject with 2 steadily mounted cameras with identical lenses and settings but from a different angle. i.e. a small distance apart. Works in the same way as our brain matches the 2 pictures from our 2 eyes.

- STOP** (Also see F number) A term used when referring to aperture settings. One stop less lets twice as much light through, and one stop more allows only half the amount of light to pass.
- STROBE** Flash unit in waterproof casing for producing artificial light assistance underwater. Sometimes quite large but neutrally buoyant.
- SYNCHRONISED FLASH** Flash which is automatically fired when the shutter is fully open. Flash has to be connected to the camera system. Synchronisation varies with type of shutter and type of flash unit.

T

- TELEPHOTO LENS** Lens with a focal length greater than the diagonal of the film used. (See normal lens).
- This type of lens magnifies the image, the results in a larger and closer image than a standard lens.
- TTL (THROUGH THE LENS) METERING** A metering system using cells inside the camera that react only to the light travelling through the lens.
- This type of exposure metering is very accurate since the meter reading is not affected by outside of the picture area.

U

- UNDEREXPOSURE** A situation where insufficient light is permitted to reach the film or photographic paper to allow a clear bright image.
- UNDERWATER CAMERA** Camera for use under water which has a strong water/pressure resistant casing and large easy to use controls. Popular cameras range from the simple "Sea and Sea", through the "Nikonos" to the "Hydroscan".

UNDERWATER CAMERA
HOUSING

A watertight container with a transparent front and an easy grip frame used to house an ordinary camera for use under water. The transparent case is usually corrected for the different properties of light in water. The camera has to be set up on the surface and will have an automatic winder which allows simplicity of use under water i.e. diver only operates shutter release. Provided the system is correctly prepared on the surface it can be a very sturdy system for underwater use.

UNDERWATER
PHOTOGRAPHY

Because of the delicate nature of normal photographic equipment special systems have been designed for underwater use. They have to be waterproof, sturdy, simple to operate, easy to handle and still provide good results. Basic systems comprise underwater camera or camera in underwater housing, flash arm, strobe and probe for close up work.

V

VIEWFINDER

A screen through which the photographer can see the field of view of the lens.

W

WIDE ANGLE LENS

Lens which has a focal length shorter than the diagonal of the film used. This type of lens has a wide angle of view and incorporates a larger subject area than a standard lens.

Z

ZOOM LENS

A lens with a variable focal length. Not used subsea on still cameras.

2.6 VIDEO

Term

Definition

B

BLACK AND WHITE
VIDEO SYSTEM

This system produces monochrome images where colours only appear as different shades of grey. Simple, cheaper system with good resolution and definition for detail work but does lack the colour definition.

BLOOM

Unfocused ball of light caused by the camera's inability to produce an accurate image in the presence of intense reflected light.

BURN

A scar on the target area of the camera caused by over exposure to an area of intense light. It may persist for a long time or be permanent and it excludes further image detection by that part of the "camera eye".

C

CAMERA HOUSING

A water tight container for camera used in underwater operations.

CCTV - CLOSED
CIRCUIT TELEVISION

This system comprises camera, surface control unit, videotape recorder and monitor connected in a circuit closed to outside broadcasts. i.e. monitor can show only what is recorded by the camera connected to it.

CLOSE UP VIDEO

Technique for detailed inspection where the camera is held close to the subject (5 to 50cm).

COLOUR VIDEO
SYSTEM

A system for producing colour images. It is a bulkier camera, has lower resolution and definition and is more expensive than black and white video systems.

COME BACK A direction command to the diver, which means pull camera away from subject to take in a larger area.

COME FORWARD A direction command to the diver, which means push the camera nearer to subject to get more detail.

D

DUBBING Sound effects or commentaries added to a video tape over a picture sequence after the pictures have been recorded.

E

ESTABLISHING SHOT A particular sequence of pictures showing the general area to establish position and orientation of particular subject.

EDIT To review and extract the desirable sections from video tape(s) and arrange them in sequence.

EDITING UNIT Device used to facilitate editing.

F

FLARE Brightness on the video monitor caused by illumination held too close to subject.

H

HAND-HELD CAMERA One of 2 types (also hat mounted) of video camera. The hand-held types give more control over content of the picture and are steadier, as the diver can actually see the direction of the camera. It does mean though, that the diver cannot carry out other operations while video is being run.

HAT MOUNTED CAMERA Video camera mounted on diver's hat. It frees hands for other operations and can be run at all times allowing constant visual contact with diver but gives a lesser degree of control by diver.

HEAD-UP DISPLAY Diver helmet display of video output (as used on ultra scan III. When the Diver is advised of the u/t screen output whilst he is u/t scanning subsea).

'IVIS' Integrated visual imaging system (trademark). Links still cameras and video through a computer or computer inspection system.

L

LAG A flare trail across the monitor screen after the camera has picked up a highly reflective, moving object.

LONG SHOT Camera held at long stand-off distance to allow viewing the entire area of a large subject.

M

MID SHOT Camera held closer to subject than long shot to take in about half of a large subject body.

MIDWATER SHOT Camera held pointing out into dark sea to show no obstacles to leave a blank screen during video run to allow titles to be added to video.

MONITOR The screen on deck showing video coverage is a monitor not a TV screen. It is tuned only to the camera being used and is not a TV receiver.

**MOVE UP/DOWN/
LEFT/RIGHT** Command to diver to move the camera in the stated direction without changing the viewing direction of the camera. i.e. move the camera normal to the viewing axis. N.B. not the same as Pan or Tilt.

P

PAN RIGHT/LEFT Command to the diver to turn the camera in the stated direction without changing position. N.B. not the same as Move.

R

RATE OF COVERAGE The speed at which the camera is moved, panned or tilted to view different parts of subject. It controls length of time any one point on subject is viewed on screen.

REMOTE CONTROL DEVICE A device for controlling video system from a distance.

ROTATE RIGHT/LEFT Command to diver to rotate the camera around its viewing axis to alter the orientation of the picture on the monitor screen. The actual position or view angle does not change.
N.B. Not the same as pan or tilt.

S

SIT CAMERAS Silicon Intensified Target (SIT) cameras which provide a high resolution picture in very low ambient lighting conditions.

STAND OFF DISTANCE Distance camera is held from subject. Close-up
5-50cm Mid 50cm - 2m - depends on visibility
Long over 2m - depends on visibility

SURFACE CONTROL UNIT Control box for camera usually situated near monitor. It controls focusing of camera and intensity of illumination lamp.

SURVEY COMMENTARY Verbal description of subject pinpointing areas of interest and detailing anomalies, carried out by diver with directions from co-ordinator during progress of inspection, or by co-ordinator dubbing a more fluent script over the original sound.

TILT UP/DOWN Command to the diver to angle the camera in the stated direction without changing position. N.B. not the same as Move.

T.V.P. CAMERA Trade name - Television Photographic. This is a combined television and stills camera operating through the same lens system. Partially removes the problem when performing a photographic survey from an ROV using the T.V. camera as a viewfinder.

U

UMBILICAL The cable between camera and monitor to carry out the electrical signals transmitted from the camera. It has to be long enough to connect the monitor, at the surface, and camera, which could be on the seabed.

V

VIDEO CASSETTE A case containing a reel of video tape.

VIDEO RECORDER A machine dedicated to record and play back motion pictures from video cassette.

VIDEO TAPE A magnetic tape used for recording motion pictures from a video camera.

VIDEO TYPEWRITER
(See also IVIS) A machine with a basic typewriter keyboard and computerised circuitry to allow script to be recorded on top of any picture which is also recorded, to provide a neater and more professional finish to the record of a particular inspection, and to highlight and identify features of interest.

2.7 PLANNING AND REPORTING

<u>Term</u>	<u>Definition</u>
	A
ABBREVIATIONS	Abbreviations of diving operations are widely used, e.g. SDV - saturation dive. These can vary from client to client but their meanings and/or uses are detailed in most procedures manuals or clients Rep's handbooks.
ABS	American Bureau of Shipping. American shipping certifying authority equivalent to Lloyds in U.K.
ANOMALY	Any non-conformance of an item to specified requirements, prior to engineering confirmation.
ASSIGNABLE CAUSE	A factor that can be detected and identified as contributing to a change in a quality characteristic.
ATTRIBUTE	A characteristic that is appraised in terms of whether it meets or does not meet a given requirement. e.g. anode wastage, extent of corrosion, extent of debris.
	B
BEAUFORT SCALES FOR WIND & SEA STATE REPORT	Wind strength and sea state are generally reported by speed (knots) and direction, and wave height (metres) every 3 or 4 hours in a 24 hour period. However, the "Beaufort Wind Scale" and "Sea State" tables may be used instead. (See relevant entries in the "Meteorology" section).
BELL TURN ROUND TIME	Time after divers in the water have completed a shift of work, when the bell is brought to the surface to let fresh divers change places with them and the bell is subsequently put back in the water.

BLOCK Sub division of sea area licenced to a company or companies for exploration/production rights. Size: 10 minutes latitude by 12 minutes longitude.

BUREAU VERITAS French Certifying Authority equivalent to Lloyds Register of Shipping in U.K.

C

CERTIFYING AUTHORITY An agency approved by and acting on behalf of a government body. The primary responsibility of the Certifying Authority is to be satisfied that the measures taken by the 'installation' owner to comply with his statutory obligations are adequate and effective and, when so satisfied, to issue a Certificate of Fitness.

CERTIFICATE OF FITNESS A government requirement which allows the continued operation of an 'installation'. Issued by a Certifying Authority and valid for 5 years, allows a five year inspection plan to be carried out before renewal.

CLIENT The party of the contract who requires the service outlined in the contract and pays for the service on completion of the contract. e.g. the oil company which owns or operates the installation being inspected.

CONTRACT An agreement, usually written, covering the terms under which services are to be performed.

CONTRACTOR The party of the contract who provides the service outlined in the contract e.g. the diving company.

CRITERION A standard of judgement.

CRITERIA OF NON-
CONFORMANCE

Maximum and/or minimum values pre-set by engineering calculation or assessment or a statement defining the acceptable parameters of a given attribute.

- e.g. (1) CP measurement less negative than -0.8V or more negative than -1.2V.
(2) Severe volumetric anode wastage (75%-100%).
(3) Metallic debris in contact with the structure.

CRITICAL DEFECT

A defect that analysis, judgement and experience indicates is likely to result in hazardous or unsafe conditions.

D

DAILY TELEX

Report completed daily and sent by telex to allow constant monitoring of the progress being made through the workscope. It will also include personnel and supplies status onboard and will also notify any requests from the ship, receipts of supplies etc. and a plan of work for the following day.

DATA SHEETS

Individual sheets which are designed to record the inspection data for each task or group of tasks.

DEFECT

Any non-conformance of an item to specified requirements, after engineering confirmation.

D.En.

Department of Energy. Government body in Britain which controls the legislation for offshore operating structures and authorises agencies to act on its behalf on the enforcement of the offshore regulations.

DEPTH OF BURIAL

The extent to which the pipeline is buried usually given as a fraction of pipe buried. e.g. pipe $\frac{1}{4}$, $\frac{1}{2}$ or $\frac{3}{4}$ buried.

DIVE PLAN

A plan prepared before the start of diving activities to assist the operations and inspection personnel in different aspects such as safety, access, depth, worksite, equipment and type of task; to perform the task efficiently.

DIVE CREW

Employees at a dive site whose work is related to diving operations; dive supervisors, divers, tenders and other surface support personnel.

DIVE LOG

The employer's log that records the events and data of a specific dive.

DIVER GRADES

Diver grades and qualifications have been subject to changes during 1984. Full details can be found in NUS/AODC/Divers agreement pamphlet "Offshore Divers Grading and Advancement Scheme".

The grades and qualifications detailed in the above pamphlet are not statutory but are recommended and have been agreed upon by the diver's union and some of the diving contractors. However, a statement from a competent diver's employer is also sufficient to grade a diver in either the Air or Saturation diving range (this has been known as the "Grandfather Clause").

The main categories as recommended in the "Offshore Diver's Grading and Advancement Scheme" are summarised opposite:

<u>Category</u>	<u>Qualification</u>	<u>Status</u>
<u>Air Diver</u>		
AD3	HSE Part 1 (Basic Air Course)	Trainee Diver
AD2	2 years as AD3 or 100 Dives	General Diver
AD1	4 years as Air Diver and Min 100 Dives	Lead Diver

Gas Diver

GD3	AD2 with HSE Part 2 (Mixed Course Gas)	Trainee Bell Diver
GD2	1 year as GD3 with min 135 hours Locked Out	General Bell Diver
GD1	5 years Diving - 2 ¹ / ₂ as GD, 390 hours Locked Out. (N.B. 1 Bell run taken as 3.5 Lock Out hours)	Senior Gas Diver

Life Support Technicians

A.LST	Trained Bell Diver or AODC Theory Exam	Assistant
LST	Bell Diver with 30 days as A.LST or A.LST with 200 days on the Job	Chamber Op.
S.LST	200 days as LST with 4 years in Diving Indust.	Supervisor

DIVER INSPECTOR
QUALIFICATIONS

Due to the increasing recognition of the importance of underwater inspection and the need for proper training of those carrying out the inspection, various bodies have introduced a specialised underwater inspection qualification which most clients now require diver inspectors to hold. The most common of these being the CSWIP qualification which has two grades - 3.1U, 3.2U. (See Weld Inspection Section, "Inspector Qualifications").

DIVERS LOGBOOK

A bound, personal record containing recorded dives, training courses, medical examinations, and diving-related illnesses and injuries.

DIVE SITE

In open-water diving, the vessel, group of vessels, and/or structures from which dives and underwater work are conducted. For inshore diving this may include adjacent piers or land.

DIVING CONTRACTOR

In relation to any diving operations, means a person who employs under contract of service all divers engaged to carry on diving operations, and where there is no such person, shall be:

(a) In the case of offshore installations and pipeline works, the concession owner, the owner of the proposed pipeline or the owner of the craft in connection with which those diving operations are to be carried on.

(b) In all other diving operations to which these Regulations apply, any diver employed under a contract for services.

DIVING SUPERVISOR

In relation to any diving operations, the competent person who has been appointed in writing in relation to these operations, by the diving contractor.

DIVING SEASON March/April to September/October, most diving operations in the North Sea are completed within this season because during the winter months the frequency of weather creating conditions too rough for diving increases significantly.

D.n.V. Det norske Veritas. Norwegian shipping certifying authority equivalent to Lloyds Register of Shipping in U.K.

DOWNTIME The time during which the vessel or equipment is not able to operate owing to bad weather, technical breakdown, or other factors.

D.S.V. Diving Support Vessel

E

EXCURSION LIMITS Depth limits above and below a divers storage depth beyond which he cannot work for any period of time and still return to his original storage depth. Tabulations of these can be found in diver's saturation diving manual or operating procedures.

F

FIVE YEAR INSPECTION PROGRAMME Because a certificate of fitness is valid for five years, owners are allowed to plan their inspection programme over this period. Provided the Certifying Authority are satisfied with the inspection results these will be credited against the major survey. In some cases the inspection itself is carried out over four years, leaving the fifth free for any necessary maintenance or repair which will need a successful re-inspection after completion.

FIX NO. A number given to an event while recording its position. It is generally used during pipeline or site surveys to locate features of interest.

G

GOVERNMENT BODIES	<p>Civil service department of national government system responsible for issuing and updating regulations concerning operations relative to their field of interest.</p> <p>Department of Energy primarily involved for operations, however Department of Transport is responsible for safety equipment surveys and the Civil Aviation Authority for helicopter operations. Also Health and Safety Executive.</p> <p>Ministry of Agriculture, Food and Fisheries.</p> <p>Ministry of Defence.</p> <p>Department of the Environment.</p> <p>Department of Employment.</p>
GERMANISCHER LLOYD	<p>German Certifying Authority equivalent to Lloyds Register of Shipping in UK.</p>

I

INSPECTION	<p>The process of measuring, examining, testing, gauging or otherwise comparing the item with the applicable requirements.</p>
INSPECTION BY ATTRIBUTES	<p>Inspection whereby certain characteristics of an item are assessed with or without measurement and classified as conforming or not conforming to specified requirements.</p>
INSPECTION BY VARIABLES	<p>Inspection where certain characteristics of an item are evaluated against a numerical scale and expressed as points along this scale.</p>

INSPECTION HISTORY Previous inspection data, and documentation arranged and presented in order of occurrence.

INSPECTION PRIORITIES Priorities are given to particular areas of interest in any one year of an inspection programme, eg critical areas - Priority 1 such as nodes Other areas are given a lower priority and may not be inspected one year but are given a higher priority the next so that the whole inspection programme is completed within the five year period.

INSPECTION PROCEDURES A set of background information and instructions for using inspection and NDT equipment and performing inspection activities.

INSPECTION REPORT A factual document describing the conditions observed during inspection.

The basic elements of the composition of a good report are:

- sufficient information
- organised presentation
- clarity of expression
- use of common terminology

INSTALLATION (Revised by Oil and Gas Act 1982). See Section 1.1 of this Handbook.

J

JOB CARD A specific inspection task issued as a part of or a supplement to a workscope.

JOB PACK A set of instructions, together with the relevant procedures, drawings, etc. to perform a task.

K

KILOMETER POST (KP) A measurement in metres to denote the distance from the start of a pipeline.

L

LICENCE Production licence allows a company to search for, drill and extract oil from the licenced quadrant. Runs for four years and may be extended to seven. Thereafter the licensee may continue the licence for not more than $\frac{1}{3}$ of original area for a further term of 30 years.

Exploration licence allows geological and geophysical surveying and shallow drilling. It has a 3 year term with a possible 3 year extension.

LLOYDS REGISTER OF SHIPPING The main British certifying authority.

M

MAJOR DEFECT A defect, other than a critical defect, that is likely to result in a failure, or to reduce materially the ability to use the component for its intended purpose.

MID TERM REPORT A temporary inspection report presented during the running time of a contract outlining progress and points of interest so that planning for any possible remedial work can begin immediately. In some cases the remedial work can be completed during the same diving season.

MINOR DEFECTS A defect that is not likely to reduce materially the ability to use the item for its intended purpose.

N

NPD Norwegian Petroleum Directorate. The government body controlling oil operations in Norway, similar to D.En. in U.K.

O

OFFSHORE DIVING CREW A crew working on a rig or vessel which is so isolated that the dive crew must live on the vessel.

OPERATIONS MANUAL A manual kept by the employer which includes contingency and emergency procedures and decompression procedures and protocols appropriate to the modes of use.

ORGANIGRAM A chart explaining organisation and responsibilities of personnel.

OPERATIONS REPORT A report consisting of data and information on operational aspects of the inspection such as the vessel used, weather conditions, personnel details, work accomplished, a breakdown of time and costs.

The operations report does not generally include details of inspection data and results.

P

PLANNING FOR OTHER OPERATIONS Small changes in the task sequence to accommodate other dangerous operations, e.g. tubular lifts by crane are not allowed in the vicinity of diving operations but it may be possible to fit them in during a long bell turn-around or when changing position.

PLANNING FOR THE
WEATHER

Changing the order of task completion to keep working in different weather conditions. Since it is not good practice to work upwind of a structure it is useful for the co-ordinator to have work he can do on opposite sides at the same depth or within working excursion limits of the diver storage depth.

PROCEDURES

To achieve a degree of standardisation and safety in inspection of structures, especially in the difficult conditions of the North Sea, procedures for inspection are laid out by experienced agencies. These should be adhered to as closely as possible and if at any time a given procedure becomes unsuitable any alternative should be agreed by all parties concerned before continuation of that particular part of inspection.

Q

QUADRANT

Sub division of sea area for purposes of awarding licences for hydrocarbon exploration and exploitation. A quadrant is 1° lat. by 1° long. i.e. 30 blocks.

S

SATURATION DEPTH
PLANNING

Minor changes in the order of task completion may have to be made offshore so as not to lose diving time due to decompression of divers changing to shallower depths. This can be avoided by putting new divers in at the shallower depth.

STATUTORY

Required by law.

STORAGE DEPTH

Pressure in the divers living chamber which is kept constant and corresponds to a working depth of sea water.

STRUCTURAL INVENTORY An inventory of all elements which comprise a structure.

U

UNDERWATER INSPECTION To examine the submerged parts of installations to ensure that the integrity of installations are maintained during their operational life.

V

VARIABLE A characteristic that is appraised in terms of values on a continuous scale.

e.g. cathodic potential (CP), wall thickness measurements.

VISUAL SUMMARY DIAGRAM Diagram of the work area marked with colour code inks in relevant sections at the end of each day by the co-ordinator to provide a quick and easy reference to finished work and work still to be completed.

W

WEATHER WINDOW

- 1) A period of calm weather permitting diving operations between two spells of weather too rough to allow diving.
- 2) Relating to the Dive season say April - September.

WORKBOOK (JOB PACK) A set of working sheets designed and arranged in order to facilitate inspection activities and data recording.
A workbook generally consists of a workscope, set of drawings, and datasheets.

WORKSCOPE A document which describes in detail the amount and type of work required.

2.8 BIOLOGICAL FOULING

Term

Definition

A

AGGREGATE

Cluster of marine growth growing one on top of another forming what looks like one large growth.

ANEMONES

Soft columnar growths with spray of tentacles out of head when undisturbed. Solitary specimens may grow to 200mm high, 80mm diameter but generally smaller when in colonies.

B

BARNACLE

Hard white, sharp edged conical growths similar totiny volcano with two protecting plates over mouth. It varies in size from very small up to 40mm diameter. It may also be on fleshy stalk. (Goose Barnacle).

BIVALVE

Shellfish with two shells hinged together.

BRYOZOANS

Colonial organisms occurring as thin flat encrusting forms, fibre-like growths or coral-like structures. Hard and rough to touch, usually grey or sandy coloured.

C

CALCAREOUS GROWTH

Hard marine growth composed of calcareous and shelled organisms.

COLONY

Several of the same species growing together in the same area. Possibly originating from a single specimen.

D

DEAD MAN'S FINGERS See soft coral.

F

FANWORMS Mud or sand tubes about 200-300mm long sticking out from surface with a spray of delicate tentacles at the end when undisturbed.

G

GREEN SEAWEED Soft green plants up to 300mm long. It can be either of leafy variety (sea lettuce) or thread-like filaments.

GROWTH COVER
THICKNESS The depth from the outer surface of thick growth to the structure surface it is growing on. This should be reported to give an idea of the extent of fouling.

H

HARD CORAL Single or branching calcareous growths, hard, stone-like and firmly attached to structure.

HARD GROWTH Defined as growth with a density higher than water. (Relative density usually about 1.5). It can either be of the hard shell type, e.g. shellfish, tubeworms or the encrusting type, e.g. coral, bryozoans.

HIATELLA Medium to small bivalve, typically of rectangular shape (max. length 30-40mm) which attaches itself to structure with threads.

HYDROIDS Small plant-like colonial animals forming feathery growths usually less than 50mm high but has been found up to 300mm high.

K

KELP

Large seaweed, usually greenish brown, firmly attached by long stalk and a root-like hold fast. It can be 1-3m long.

Its leaf can be like a palm, a single crinkly frond or a single blade with a central spine.

L

LIMPETS

Smooth conical shellfish. Strongly adheres to surface by suction of single fleshy foot. Grows to as much as 50mm diameter and can move slowly over surface.

M

MUSSELS

Dark blue glossy shelled bivalve up to 100mm long attached by flexible threads. They may be as individuals, clusters or dense encrustation providing a covering often more than one individual thick.

O

OYSTER

Whitish bivalve almost circular in shape. Lower shell is flatter and firmly attached to surface, and being almost hidden from view makes it look a bit like a limpet. The type found in North Sea is the saddle oyster which grows to about 50mm in diameter.

P

PERCENTAGE COVER

To give an idea of the amount of fouling on a structure, an estimate is made of the actual surface area covered by marine growth which is given as a rough percentage of the total surface area.

R

- RED SEAWEED** Reddish plant up to 300mm high with either soft hairy form or a stiff branched form.
- RELATIVE DENSITY** The density of any particular specimen compared to water. If more dense, it would naturally sink and being fixed to the structure it adds more weight to the existing stresses on the structure. Hard growth is denser than water. Soft growth is about the same density as water and does not significantly effect the weight loading.

S

- SAMPLES** A pre-stated area of surface is stripped clean and all growth removed is stored in a sample jar and preserved in seawater solutions of 70% industrial spirit or 10% formalin.
- SEA SQUIRT** Soft and almost transparent bodied animal which looks a bit like a potato with two openings. It is up to 100mm high but occasionally, when solitary may grow to 200mm.
- SINGLE** An isolated specimen of marine life. Biologists like these to be reported also, as it allows more accurate study of the spreading of marine growth.
- SLIME LAYER** Organic molecules that form around a structure creating habitat and food store for spores of larger algae.
- SOFT CORAL
(DEAD MANS FINGERS)** Fleшы lobed growths of white of warm pastel colour. They have a fine hairy covering when undisturbed, and may grow up to 200mm long.

SOFT GROWTH Defined as growth with a density roughly equal to water. This type gives no significant change in the actual weight loading of the structure. May be plants such as seaweeds or animal life such as corals (dead mans fingers).

SPONGES Patch of soft pastel coloured tissue sticking to surface like large irregular shaped pancake, 20-30mm thick and punctured with many small holes.

S.R.B. See Section 2.9 "Corrosion and Protection".

T

THONGWEED Olive coloured bunch of leathery straps growing from a small button or "mushroom" about 1m long.

TUBEWORM One of the most common species of marine fouling found in North Sea. Worms live in white calcareous tubes which are usually all that is seen. When undisturbed fine hair-like tentacles are extended from the mouth of the tube. The solitary types can be 30-50mm long. The colonial type forms domes of fine brittle tubes about 100-300mm diameter.

W

WEIGHT LOADING Static weight or hydrodynamic loading due to accumulation of marine growth.

WRACK Brown leathery seaweeds growing in bunches with obvious bladders on the fronds 200-600mm long.

2.9 CORROSION AND PROTECTION

<u>Term</u>	<u>Definition</u>
	A
ACTIVE	In the process of galvanically corroding. An active anode is corroding and providing protection for the structure (see passive).
ANODE	An electrode or an area of material at which a net oxidation or corrosion process takes place. The most common corrosion process at anode is: $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^{-}$ The anode corrodes by giving up charged positive ions and electrons. Anode also refers to the positive terminal of the impressed current system from which current is discharged.
ANODE WASTAGE	An estimate of the amount of wasted sacrificial anode material expressed as slight, moderate, or severe.
ANODIC REACTION	An oxidation reaction which is indicated by an increase in valence or a production of electrons e.g. $\text{M (metal atom)} \rightarrow \text{M}^{n+} \text{ (metal ions)} + n\text{e}^{-}$
	B
BASIC	Associated with the reactive or basic end of the galvanic series.
BATHYCORROMETER	(Roxby) - Type of CP meter.

BIOLOGICAL CORROSION The deterioration of metal by corrosion processes which are either directly or indirectly the result of the activity of living organisms (see SRB's).

BLACK DEPOSIT A product which could be found on submerged structures and may consist of corrosion products such as iron sulphide.

BLISTER A swelling of the surface of an unbroken paint coating due to moisture, gases or corrosion products between the paint and the metal.

BOND A low resistance connection (usually metallic) provided for electrical continuity.

C

CALCAREOUS DEPOSIT A layer consisting of a mixture of calcium carbonate and magnesium hydroxide deposited on surfaces which are cathodically protected in sea water.

This deposit is a result of the increased pH adjacent to the protected surface.

CALIBRATION To check the reference electrode or half cell before use with one or more small blocks of material of known potential. e.g. a CP in the order of -1.04 volts with respect to silver/silver chloride half cell is obtained by using high purity zinc for calibration.

A piece of rusting steel should read in the order of -0.4 to -0.65 volts.

Calibration blocks should be attached to the CP meter to allow calibration checks at the actual worksite.

CALOMEL CELL A reference electrode or half cell used for potential measurements.

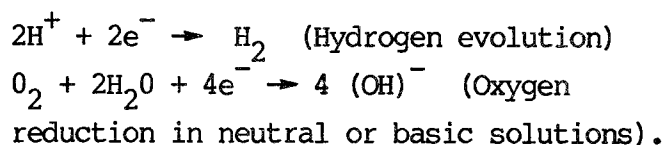
CATHODE An electrode or an area of material at which a net reduction reaction takes place, (e.g. submerged structures).

A cathode receives electrons and is protected from corrosion, (also see "Cathodic Reaction").

CATHODIC PROTECTION (CP) A technique to prevent corrosion and protect a metal structure by making it the cathode of an electrochemical cell.

It is based on passing sufficient cathodic current to a metal surface to cause its anodic dissolution rate to become negligible.

CATHODIC REACTION A reduction reaction which is indicated by a decrease in valence charge or the consumption of electrons. The main cathodic reactions in seawater are:



CAVITATION A form of erosion corrosion which is caused by formation and collapse of vapour bubbles in a liquid near a metal surface. The collapse produces shock waves with very high pressures.

Cavitation damage occurs where high-velocity liquid flow and pressure changes are encountered.

COATING/INSULATING COATING SYSTEM All components comprising the protective coating system, the sum of which provides effective electrical insulation of the coated structure from the electrolyte, thus breaking the corrosion cell circuit at the electrolyte path.

CONCENTRATION CELL CORROSION Any build up of ions of particular charge in the electrolyte close the the structure causes potential differences in the steel which accelerate corrosion at the less negative areas. This build up of ions can take place anywhere there is no water circulation (shadow zone or area). Crevice corrosion is a form of concentration cell corrosion. Marine growth can increase the chances of occurrence of concentration cell corrosion.

CONTINUITY BOND A metallic connection that provides electrical continuity.

CORROSION Corrosion may be defined as chemical or electro-chemical degradation of materials (usually metals) as a result of reaction with their environments.

CORROSION CELL Combination of an anode, a cathode, an electrolyte and an electrical path (metallic contact) to allow the corrosion process to occur.

CORROSION FATIGUE Synergistic effects of corrosion and fatigue which work together to cause failure of a material subject to cyclic stresses in corrosive environment in fewer cycles and at lower stress than under non-corrosive conditions.

CORROSION INHIBITOR A chemical compound, either organic or inorganic, which when added to the environment in the proper concentration and form, controls or reduces corrosion.

CORROSION RATE Quantitative expression of the rate of attack for a given material.

CP/CP MEASUREMENT

Refers to a cathodic potential between the structure surface and a reference electrode (such as silver/silver chloride).

This is always quoted as a negative value in millivolts or volts.

CP METER

A device for measuring potential between the structure surface and a reference electrode (such as silver/silver chloride). The voltage is measured across the electrolyte path but an earth has to be established with the structure. Hand held units such as the Roxby Bathycorrometer or Morgan Berkeley Rust Reader have an earthing tip which is pressed into the structure and a direct read out display which is read and relayed to the surface by the diver. "Flying Probe" units need to be earthed by cable to the structure and a probe on an umbilical is used by the diver. Measurements are displayed on a meter on the surface. Both types should be calibration checked at the work site.

CREVICE CORROSION

Crevice promote the formation of concentration cells. The oxygen in the crevice may be consumed more rapidly than fresh oxygen can diffuse into the crevice, and chloride ions diffuse into the crevice to maintain a balance of charge. This causes a decrease in pH in the crevice which accelerates corrosion.

Metals or alloys which depend on oxide layers or passive films for corrosion resistance are particularly susceptible to crevice corrosion.

CURRENT

Rate of flow of electrical charge carriers in direction of net transport of positive charges. In a metallic conductor, this is the opposite direction to electron flow. Current is expressed in amperes or milli amperes.

CURRENT DENSITY

The electric current per unit area. It is frequently expressed as milli amperes per square foot (mA/ft^2) or milli amperes per square meter (mA/m^2).

D**DEPOLARISATION**

The elimination or reduction of polarisation by chemical or mechanical methods.

DIELECTRIC SHIELD

An electrically non conductive material which is placed between the anode and the adjacent cathode to avoid current wastage and to improve current distribution on the cathode.

e.g. coatings, prefabricated plastic or elastomeric sheets, plastic pipe sleeves, and coated stand offs or supports for impressed current anodes.

**DIFFERENTIAL
AERATION CELL**

In regions with a differential supply of oxygen, the areas with a greater supply of oxygen may tend to become cathodic with respect to the area with less oxygen which becomes anodic. For example, at an air/water interface, the water at the surface contains more oxygen than the water slightly below the surface and the differential concentration can cause preferential attack just below the water line.

DOUBLER PLATE

An additional plate or thickness of steel used to provide extra strength at the point of attachment to a platform or riser, (eg. for an anode).

E**ELECTRICAL
ISOLATION/ISOLATION**

The condition of being electrically separated from other metallic structures or the environment.

ELECTRICAL PATH

A metallic path between the anode and cathode to allow corrosion process to take place.

**ELECTRODE
POTENTIAL** The potential of an electrode as measured against a reference electrode (this does not include any loss of potential in the solution due to current passing to or from the electrodes).

ELECTROLYSIS The dissociation of an electrolyte by passage of direct current, in which anions (negative ions) are discharged at the anode and cations (positive ions) at the cathode.

ELECTROLYTE A chemical substance or mixture, usually liquid containing ions that migrate in an electric field, and provide an ionic conductor of electric current. e.g. soil or sea water in contact with a buried or submerged metallic structure.

EROSION CORROSION The accelerated corrosion caused by the corrosion products being eroded as they form leaving clean metal exposed all the time. Most frequent in bends of pipe carrying corrosive or abrasive materials, e.g. crude oil risers.

F

**FLYING PROBE
(STAND-OFF PROBE)** Probe on a cable for taking CP measurements. System has a surface readout meter and a separate earth. Normally used with a set stand-off.

FRETTING CORROSION The corrosion occurring at contact areas between materials which have relative movement against each other.

Fretting corrosion has the appearance of pits or grooves in the metal surface surrounded by corrosion products. The pits and grooves formed act as stress raisers and can cause fatigue fracture.

G

**GALVANIC CORROSION/
BIMETALLIC CORROSION** A potential difference usually exists between two dissimilar metals when they are immersed in a conductive solution.

If these metals are in electrical contact, a flow of electrons from the more active metal (anode) to the more noble metal (cathode) takes place. The corrosion of the more active metal is usually increased and attack on more noble metal is decreased, compared with the behaviour of these metals when they are not in contact. The two dissimilar areas may be on a single piece of material due to variation in the micro structure.

GALVANIC SERIES A list of metals and alloys arranged according to their relative potentials in a given environment. The materials on the passive end of the series are cathodic or noble and the ones at the reactive end are anodic or active.

GALVANISATION Coating which is zinc based which allows galvanic corrosion between zinc and the steel. The zinc corrodes and the steel is protected.

**GENERAL OR UNIFORM
CORROSION** A situation where corrosion proceeds uniformly over the material surface. Allowances for this type of corrosion can be made in the design phase.

GROUND An electrical connection to earth.

H

**HALF CELL
REFERENCE ELECTRODE** See Reference Electrode.

HOLIDAY A discontinuity of coating that exposes the metal surface to the environment.

HYBRID SYSTEM A cathodic protection system consisting of sacrificial anode and impressed current systems, or any other mixture of protection systems, e.g. paint and sacrificial anodes.

I

IMPRESSED CURRENT Direct current supplied by a power source external to the electrode system.

This electric current is used in one type of cathodic protection system for protecting offshore installations.

IMPRESSED CURRENT ANODE A material used in impressed current cathodic protection system, made of lead-silver alloy, platinum over various substrates, lead-platinum, graphite, silicon-iron, etc.

IMPRESSED CURRENT SYSTEM A cathodic protection system where impressed current anodes are connected with an electrically insulated conductor either singly or in groups, to the positive terminal of a direct current source such as a rectifier or generator.

The platform to be protected is connected to the negative terminal of the direct current source.

INSULATION Neoprene liner inside riser clamps to separate pipelines from jackets.

INTERGRANULAR CORROSION The preferential attack to grain boundaries as a result of a metallurgical structure that causes the grain boundaries to be more susceptible to attack than the grains.

It can occur in many alloys particularly austenitic stainless steels.

In general proper heat treatment can eliminate susceptibility to intergranular corrosion.

This type of attack should not be confused with stress corrosion cracking where stress plays an important part.

IR DROP The voltage across a resistance in accordance with Ohm's Law.

N

NOBLE METALS The materials with excellent corrosion resistance. Opposite of active.

Due to their high cost, they are referred to as precious metals, e.g. gold, silver, platinum.

O

OVER-PROTECTED If the surface of material receives excessive protection against corrosion, it is said to be "over-protected".

For example, if the CP in sea water is more negative than -1.2 volts with respect to silver/silver chloride half cell, the structure is over-protected. Overprotection results in excess hydrogen evolution and could cause hydrogen embrittlement.

P

PASSIVATION A reduction of the anodic reaction rate of an electrode involved in electrochemical action such as corrosion. A sacrificial anode can be made passive by breaking its electrical contact with the structure.

pH The negative logarithm of the hydrogen ion concentration in an electrolyte giving an indication of acidity, neutrality or alkalinity. The pH scale is such that:

pH = 7 Neutral environment (pure water)

pH between 0 and 7 = Acidic environment

pH between 7 and 14 = Alkaline or basic environment

PITTING	A form of corrosion where the metal under attack suffers metal loss at localised areas, and the corrosion rate in those areas is many times greater than the average corrosion rate over the entire surface. Pits act as stress raisers and can lead to sudden failures.
POLARISATION	The change of potential of a metal surface resulting from the passage of current directly to or from an electrolyte.
PREFERENTIAL CONSUMPTION	Loss of material from sacrificial anode which corrodes preferentially to the steel.
PROXIMITY METER	Type of CP meter (see Flying Probe).
R	
RATE OF PROTECTION	Speed at which an anode corrodes providing ions and electrical protection. This is reduced over a period of time as the anode is used up.
RED/BROWN/ORANGE DEPOSIT	A corrosion product consisting of hydrated iron oxides which could be found on submerged structures.
REDUCED FATIGUE LIFE	Loss in the working life of a material subjected to cyclic stresses. Related to corrosion in that stress raisers can be produced by the corrosion process (pits).
REDUCED WALL THICKNESS	Thinning of the metal body caused by corrosion.
REFERENCE ELECTRODE/REFERENCE HALF-CELL	A device whose open circuit potential is constant under similar conditions of measurement, and is used for comparisons with structural potentials.
RUST	A corrosion product in iron-base materials consisting of iron oxides and usually is hydrated ferric oxide.

RUST READER

(Morgan Berkeley) - Type of CP meter.

S

- SACRIFICIAL ANODE/
GALVANIC ANODE A metal piece (e.g. zinc, aluminium and magnesium alloys) which provides sacrificial protection to another metal structure that is more noble when coupled in an electrolyte. These anodes are the source of electric current in one type of cathodic protection system which utilises sacrificial anodes.
- SACRIFICIAL ANODE
SYSTEM/
GALVANIC ANODE SYSTEM A cathodic protection system where sacrificial or galvanic anodes are used to deliver adequate protection current to a structure with maximum efficiency of current distribution.
- SACRIFICIAL
PROTECTION Reduction or prevention of corrosion of metallic material in an electrolyte by galvanically coupling it to a more anodic material.
- SHEATHING/
CLADDING A method of protection which involves covering the steel with an airtight coat of corrosion resistant material, e.g. monel.
- SILVER-SILVER
CHLORIDE ELECTRODE/
SILVER-SILVER
CHLORIDE HALF CELL A reference half cell comprising a silver electrode in a saturated solution of silver chloride which has a constant potential against which others can be compared.
- SOUR CORROSION/
HYDROGEN SULPHIDE
(H₂S) ATTACK A form of corrosion caused by hydrogen sulphide dissolved in water which behaves as a weak acid and usually causes pitting.

The metal reacts with the hydrogen sulphide and water to produce metallic sulphides which generally adhere to the metal surface in the form of a scale or black powder.

Because the metallic sulphide is cathodic to the metal, the scale tends to cause local acceleration of corrosion usually resulting in deep pitting.

S.R.B. (SULPHATE REDUCING BACTERIA)	This is a form of micro-organism which promotes biological corrosion. In anaerobic environments, SRB's have the ability to convert sulphate ions to hydrogen sulphide. The hydrogen sulphide then reacts with the metal to produce a metallic sulphide scale which is cathodic to the metal. This results in corrosion of the scale-free area.
STEEL-TO WATER POTENTIAL	The potential difference between a steel surface and a reference electrode immersed in the water with which it is in contact.
STRAY CURRENT/ INTERFERENCE CURRENT	A direct current flowing through paths other than the intended circuit. It is the current discharged to the electrolyte from a structure which is not an intended part of the circuit or, if intended, not adequately connected to the current source.
STRAY CURRENT CORROSION	Corrosion resulting from electric current which flows through paths other than the intended circuit.
STRESS CORROSION CRACKING	The cracking caused by simultaneous presence of stress and a specific corrosive environment. The result of the combined effect is a brittle failure of a normally ductile metal. The stress can be either a residual stress or an applied stress (e.g. tensile). In many cases pitting precedes cracking, with stress corrosion cracks developing from the base of the pits. The cracking may be either intergranular or transgranular. The residual stress in a steel can be enough to cause grains to take different potentials and act as dissimilar metals in intergranular corrosion.
STRUCTURE-TO-ELECTROLYTE VOLTAGE OR POTENTIAL	The voltage difference between a buried or submerged metallic structure and a reference electrode in contact with the electrolyte.

STRUCTURE-TO-
STRUCTURE VOLTAGE
OR POTENTIAL

The difference in voltage between metallic structures in a common electrolyte.

SWEET CORROSION
CO₂ CORROSION

A form of corrosion caused by carbon dioxide dissolved in water which forms carbonic acid. This decreases the pH of the water and increases the corrosivity which usually results in pitting. The pressure, temperature and composition of the water govern the solubility of carbon dioxide.

U

UNDER-PROTECTED

If the surface of material does not receive sufficient protection against corrosion, it is said to be "under-protected".

For example, if the CP in seawater is less negative than -0.8 volts, the structure is under-protected, and this could result in corrosion.

V

VOLTAGE

An electromotive force, or a difference in electrode potential, expressed in volts.

2.10 GENERAL DEFECTS

<u>Term</u>	<u>Definition</u>
A	
ABRASION	A scratch mark on the material surface caused by rubbing or scraping away.
ANODE CONDITION	(Pipeline) Condition of an anode on a pipeline expressed as: <ul style="list-style-type: none">- Disconnected- Inactive 0% wastage- Lightly Active 0-20% wastage- Active 10-20% wastage- Severely Active >20% wastage- Consumed >50% wastage
ANOMALY	A defect with values outside the criteria of non-conformance.
ATTRIBUTE	A characteristic that is appraised in terms of whether it meets or does not meet a given requirement.
B	
BUCKLING	Bending out of true of a member under compressive stress.
C	
CONCRETE SPALLING	(Pipeline) Damage to the surface or flaking of the concrete weight coat of a pipeline down to the reinforcement.
CORROSION	Disintegration or deterioration of reinforcement or metal by electrolysis or by chemical attack.

CRACKS An incomplete separation into one or more parts with or without space between. They can be classified by direction, width and depth.

CRITERIA ON NON-CONFORMANCE Maximum and/or minimum values preset by engineering calculation or assessment. A defect with values outside the criteria of non-conformance becomes an "anomaly".

CRITICAL SPAN The maximum safe span length specified for a given pipeline above which the span is considered to be critical.

D

DEBRIS Scrap material dropped over the side of installations. The most common types of debris are wire rope, softline, scaffolding, grating, cable trays and miscellaneous metal sections. Debris could be hazardous to the diver, obstructs inspection, can cause corrosion where metallic contact is made and is potentially a cause of physical damage.

DEBRIS (Pipeline) Items such as 45 gallon drums, cables and wire ropes, large fishing nets, large rocks and boulders which are likely to damage the pipeline.

DISCOLOURATION Departure of colour from that which is normal or desired.

DISINTEGRITY OF APPURTENANCES Lost or loose bolts or fixings, broken wires or other articles, misalignment or other deteriorations which indicates previous damage and/or may result in future damage.

DISINTEGRITY OF COATINGS Defects such as blisters, flaking, scratches and loss of coating. They may also be indications of other more serious physical damage which may have taken place.

DISINTEGRITY OF
STRUCTURE

Broken or missing structural components.

E

EROSION

Deterioration brought about by the abrasive action of fluids or solids in motion.

F

FOULING

The mass of living and non-living bodies and particles attached to or lying on the surface of a submerged man-made or introduced object: more commonly considered to be only living or attached bodies.

FRACTURE

A break or discontinuity in material. This may be caused by internal stresses in material or overloading.

FREESPAN

(See "Span")

H

HOLES

Cavities in materials caused by outside forces.

I

INDENTATION

A recess or dent in material caused by pressure of another object.

M

MARINE GROWTH

Accumulation of marine life. Not a defect but can cause harm to structures, such as biological corrosion, concentration cell corrosion, increases drag, increased weight in the case of hard growth, increased slam effects in the splash zone.

P

PHYSICAL DAMAGE

A general term used for features such as indentations, abrasions, buckling and fracture. These could be caused by falling debris, boat collisions, wire ropes or other solid objects, overloading or specific areas of design weakness.

PIPE DAMAGE Damage to the metal of a pipeline itself. Accurate dimensions of any pipe damage should be given during a pipeline survey.

PITTING Development of relatively small cavities in a surface due to phenomena such as corrosion or cavitation.

S

SCALE Flaky product which could be the result of hydrogen sulphide reaction with steel.

SCOUR Continuous movement (build up and removal) of seabed materials (sand, silt) caused by hydrodynamic forces of water movement round structures on the seabed. It can grow to serious proportions if left unchecked.

SPAN/FREESPAN An unsupported section of pipeline, where seabed has been eroded or pipeline not properly trenched. It can cause undue stress in the pipeline materials if its length is critical.

The "height" and "length" of the spans should be reported during the pipeline surveys.

SUSPENSION (Pipeline term) The height of the pipe above the seabed.

SUSPENSION POINT (Pipeline term) Where a pipeline is resting on a local high spot such as a boulder, leaving an unsupported span either side.

W

WEIGHT COAT DAMAGE (Pipeline term) Damage caused to concrete weight coat of a pipeline during pipelaying operations or by other objects such as anchor cable. The extent of weightcoat damage should be reported during pipeline survey.

WELD DEFECTS The weld defects are described in section 2.11.

2.11 WELD DEFECTS

Term

Definition

A

ANGULAR
MISALIGNMENT

Misalignment between two welded pieces such that their surface planes are not parallel (or at the intended angle).

ARC STRIKE

Any inadvertent change in the contour of the finished weld or base material resulting from an arc generated by the passage of electrical energy between the surface of the finished weld or base material and a current source, such as welding electrodes or magnetic inspection prods.

B

BAD REINFORCEMENT
ANGLE

Too large an angle between the plane of the parent metal surface and a plane tangential to the weld bead surface at the toe.

BRANCHING CRACKS

A group of connected cracks originating from a common crack and distinguished from disconnected cracks and from radiating cracks. They may be situated:
in the weld metal
in the heat affected zone
in the parent metal.

BURN THROUGH

A collapse of the weld pool resulting in a hole in the weld or at the side of the weld.

C

CAVITY/GAS CAVITY

A cavity formed by entrapped gas.

CHIPPING MARK

Local damage due to incorrect use of a chisel.

COLD LAP

(See "Overlap")

CRACK/FISSURE A discontinuity produced by a local rupture which may arise from the effect of cooling or stresses.

CRATER CRACK A crack in the end crater of a weld which may be: longitudinal, transverse, star cracking.

CRATER PIPE The depression due to shrinkage at the end of a weld run and not eliminated before or during the deposition of subsequent weld passes.

E

ELONGATED CAVITY A large non spherical cavity with its major dimension parallel to the axis of the weld.

EXCESSIVE CONVEXITY An excess of weld metal at the face of a fillet weld.

EXCESSIVE PENETRATION Excess weld metal protruding through the root of a weld made from one side or through weld metal previously deposited from either side of a multi-run joint.

EXCESSIVE REINFORCEMENT An excess of weld metal at the face of the butt weld.

F

FLUX INCLUSION Flux entrapped in the weld metal. According to circumstances such inclusions may be: linear, isolated, others.

G

GAS PORE A gas cavity of essentially spherical form.

GRINDING MARK Local damage due to incorrect grinding.

GROUP OF
DISCONNECTED CRACKS A group of disconnected cracks which may be
 situated:
 in the weld metal,
 in the heat affected zone,
 in the parent metal.

I

IMPERFECT SHAPE Imperfect shape of the external surfaces of the weld
 or defective joint geometry.

INTERDENDRITIC
MICROSHRINKAGE Interdendritic shrinkage only visible under the
 microscope.

INTERDENDRITIC
SHRINKAGE An elongated shrinkage cavity formed between
 dendrites during cooling which may contain entrapped
 gas. Such a defect is generally to be found
 perpendicular to the weld faces.

L

LACK OF FUSION/
INCOMPLETE FUSION Lack of union between weld metal and parent metal
 or weld metal and weld metal. It will be one of the
 following:
 lack of side wall fusion,
 lack of inter-run fusion,
 lack of fusion at the root of the weld.

LACK OF PENETRATION
(INCOMPLETE
PENETRATION) Lack of fusion between parent metal and parent
 metal due to failure of weld metal to extend into
 the root of the joint.

LINEAR MISALIGNMENT Misalignment between two welded pieces such that
 whilst their surface planes are parallel their
 projected surfaces are not at the required level.

LINEAR POROSITY A line of gas pores situated parallel to the axis of
 the weld.

LONGITUDINAL CRACK A crack substantially parallel to the axis of the weld. It may be situated:
in the weld metal,
at the weld junction,
in the heat affected zone,
in the parent metal.

M

METALLIC INCLUSION A particle of foreign metal trapped in the weld metal. It may be of:

MICRO-CRACK/
MICROFISSURE When a crack has microscopic dimensions it is known as a microfissure or microcrack.

MICROSHRINKAGE Shrinkage only visible under the microscope.

M.P.I. INDICATION A discontinuity which is detected by magnetic particle inspection technique. The indication may be continuous or intermittent.

O

OVERLAP Excess of weld metal at the toe of a weld covering the parent metal surface but not fused to it. Sometimes mis-named cold lap.

OXIDE INCLUSION Metallic oxide trapped in the weld metal during solidification.

P

POOR RESTART A local surface irregularity at a weld restart.

PROFILE DEFECTS General term applied to excess metal, misalignment, excessive penetration, root concavity, etc.

PUCKERING In certain cases especially in aluminium alloys gross oxide film enfoldment can occur due to a combination of unsatisfactory protection from atmospheric contamination and turbulence in the weld pool.

R

RADIATING CRACKS Cracks radiating from a common point. They may be found:

in the weld metal,
in the heat affected zone,
in the parent metal.

N.B. Small cracks of this type are known as star cracks.

ROOT CONCAVITY A shallow groove due to shrinkage of a butt weld at the root. (see also shrinkage groove).

S

SHRINKAGE CAVITY A cavity due to shrinkage during solidification.

SHRINKAGE GROOVE A shallow groove in the root caused by contraction in the weld metal along each side of the penetration bead. (See also Root Concavity).

SLAG INCLUSION Slag entrapped in the weld metal. According to the circumstances of their formation such inclusion may be:
linear,
isolated,
others.

SOLID INCLUSIONS Solid foreign substances entrapped in the weld metal.

SPATTER Globules of weld metal or filler expelled during welding and adhering to the surface of parent metal or solidified weld metal.

STRAY FLASH OR ARC STRIKE Local damage to the surface of the parent metal adjacent to weld resulting from accidental arcing or striking the arc outside the weld groove.

SURFACE PORE A small gas pore which breaks the surface of a weld.

T

TORN SURFACE Surface damage due to the removal by fracture of temporary welded attachments.

TRANSVERSE CRACK A crack substantially transverse to the axis of the weld. It may be situated:
in the heat affected zone,
in the weld metal,
in the parent metal.

TUNGSTEN SPATTER Particles of tungsten transferred from the electrode to the surface of parent metal or solidified weld metal.

U

UNDERCUT A groove at the toe(s) of a weld run due to welding. Undercut may be continuous or intermittent.

UNDERFLUSHING Reduction in thickness of metal due to excessive grinding.

UNIFORMLY A number of gas pores distributed in a
DISTRIBUTED POROSITY/ substantially uniform manner throughout the
LOCALISED (CLUSTERED) weld metal; not to be confused with linear
POROSITY porosity. Group of gas cavities.

V

VISIBLE DEFECT A defect which could be seen without the aid of special N.D.T. techniques. e.g. visible crack, undercut, overlap.

W

WORM-HOLE A tubular cavity in weld metal caused by release of gas. The shape and position of worm-holes is determined by the mode of solidification and the sources of the gas and they may be distributed in a herringbone formation.

3. MATERIALS AND WELD INSPECTION

<u>Term</u>	<u>Definition</u>
	A
ACPD	Alternating Current Potential Drop. An NDT technique for determining defect depth and profile. It is based on a high frequency alternating current which is passed through a conductive material. If there is a surface-breaking defect the field will follow the profile of the defect. The measurement of change in potential drop between two contacts of known distance, both over the defect and just off the defect on sound metal will enable the defect depth to be determined.
ALIGNMENT	The correct position and orientation of the two parent metal faces before welding.
ALLOYS	Metallic materials consisting of an intentional mixture of elements to obtain required properties.
API	American Petroleum Institute - A national oil trade association for standardising materials and equipment, and publishing codes of practice.
ARC WELDING	A group of welding processes, where coalescence is produced by heating with an arc or arcs. with or without the application of pressure, and with or without the use of filler metal.
ARC WELDING ELECTRODE	A component of the welding circuit through which current is conducted between the electrode holder and the arc.
ASTM	American Society for Testing and Materials, responsible for the issue of standard methods.

AS-WELDED The condition of weld metal, welded joints and weldments after welding prior to any subsequent thermal, mechanical, or chemical treatments.

B

BASE METAL The metal to be welded, soldered, or cut.

BACKING Material (metal, weld metal, carbon, or granular) placed at the root of a weld joint for the purpose of supporting molten weld metal.

BEAD See Weld Bead.

BLOW-HOLES Defects mainly due to gas blowing into the metal.

BRITTLENESS A material property to fracture without tolerating much permanent deformation, (also see "Cold and Hot Shortness").

BUTT JOINT A joint between two members aligned approximately in the same plane.

BUTT WELD Common term for a full penetration weld where the faces have been prepared to allow the filler material to be deposited across the full thickness of the parent metal. Usually for pipe and plate butt joints but also commonly used for T-butt, node and member to member configurations.

C

CAP/WELD CAP Common term for face of weld.

CHIPPING Removal of excess filler metal or spatter with chipping tools such as cold steel chisels.

CLEANING To remove marine fouling organisms and expose bare steel surfaces for detailed underwater NDT (see also section on "Inspection Techniques").

COLD SHORTNESS When steel fractures in a cold state. This type of brittleness is caused by too much phosphorus in steel.

CONCAVITY	Insufficient application of filler metal resulting in a concave face.
CONVENTIONAL WEAVE	Method of applying filler metal in a circular motion which results in a ribbed effect on each bead.
CONVEXITY	Excess application of filler metal resulting in a bulging over convex face.
CORNER JOINT	A joint between two members located approximately at right angles to each other.
CORROSION FATIGUE	Interaction of both a fatigue mechanism and corrosive environment. Corrosion accelerates the fatigue crack propagation rate.
CSWIP	An abbreviation for "Certification Scheme for Weldment Inspection Personnel". The CSWIP scheme developed under the aegis of The Welding Institute and the British Institute of NDT is operated for an independent management board representative of trade associations, insurance companies, classification societies, inspection organisations, nationalised industries, Government departments and other bodies.
D	
DEFECT	A discontinuity in the metal body which may affect the integrity of the body under working conditions.
DRESSING	Grinding or chipping of weld metal to produce a smoother or even flat profile.
DUCTILITY	A material property as a result of which a material may be drawn out in tension without fracture. It also refers to the softness of the material or its ability to be bent.

DYE PENETRANT

This NDT technique is based on a penetrant entering the defect from the surface. Once the penetrant is applied to a cleaned surface, a developer is used to draw the penetrant from the defect and reveal the surface indication.

Only defects which are open to the surface can be inspected by this method. It cannot be used underwater.

E.B. INSERT

A proprietary type of backing strip which slots into and behind the weld root and fuses with the parent metal to form the root when welding commences.

EDDY CURRENT TESTING

An NDT technique for detection of defects. It is based on interaction between a coil carrying an alternating current and a conducting metal surface/ If a discontinuity is present, a change in the voltage of the test coil will occur due to its change of impedance.

The testing equipment is very sensitive to several variables and must be used by a highly trained diver/inspector.

ELASTICITY

A material property that enables it to return to its original state after deformation when the applied load causing that deformation is removed.

ELASTIC LIMIT

The point up to which the material remains elastic and returns to its original dimension upon removal of the load. Beyond this limit, deformation is plastic and results in stress hardening of the material.

ELASTIC MODULUS

(Young's modulus, E) This is calculated by dividing any stress, within the elastic limit, by the corresponding strain.

$$E = \frac{\text{Stress}}{\text{Strain}}$$

ENDURANCE LIMIT The value of the stress condition under which the test specimen has a life of N cycles.

F

FABRICATION DEFECTS Defects resultant in the fabrication stage of a structure due to incorrect procedures. These should have been detected and dealt with at that stage.

FACE OF WELD/WELD
FACE The exposed surface of a weld on the side from which welding was done. (See also "Cap").

FATIGUE A failure in materials subjected to many cyclic stresses below the materials elastic limit. A fluctuating load can cause a crack to propagate through a material even when the load is well below the yield point for the material.

Fatigue data is usually plotted as stress against number of cycles to failure (S-N Curves), drawn for a particular material under specific conditions.

FATIGUE DEFECTS See "In Service Defects".

FATIGUE LIMIT The value of the stress condition below which a material may endure an infinite number of stress cycles.

FILLET WELD A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, tee joint, or corner joint. The actual faces of the parent metal are not fused together, therefore, fillet welds do not carry stress well and should not be used in highly stressed areas.

FLUX A material to aid fusion of filler and parent metals which is melted by the welding arc. Fluxes may be granular or solid coatings. Fluxes serve to stabilise the welding arc, shield all or part of the molten weld pool from the atmosphere, and may or may not evolve shielding gas by decomposition.

FLUX CORED WELDING See "Inner Shield".

FULL PENETRATION Type of weld where filler metal is applied and fusion takes place across the full width of the parent metals. This type allows stress to be successfully transmitted from one parent metal to the other when in use.

FUSION The melting together of filler metal and base metal, or of base metal only, which results in coalescence.

FUSION LINE In a weldment, the interface between weld metal and base metal, or between base metal parts when filler metal is not used. Also called "Bond Line".

FUSION ZONE The area of base metal melted as determined on the cross section of a weld.

G

GAS METAL-ARC (GMAW) An arc welding process wherein coalescence is produced by heating with an electric arc between a filler metal (consumable) electrode and the workpiece. Shielding is obtained from a gas, a gas mixture (which may contain an inert gas) or a mixture of a gas and a flux. (This process has sometimes been called MIG Welding).

GAS TUNGSTEN ARC WELDING (GTAW) An arc welding process which produces coalescence of metals by heating them with an arc between a tungsten (nonconsumable) electrode and the work. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This process has sometimes been called TIG welding).

GRINDING	Mechanical method of removing small areas of metal using rotary burrs.
H	
HARDENABILITY	The ability of a material to be hardened by quenching. The way in which the hardness of a quenched piece of steel falls away from the outside to the centre is a measure of its hardenability. (Jominy Test) Generally, faster cooling gives hard microstructure. The rate of cooling is affected by increasing carbon content and alloying constituents.
HARDNESS	A material property affecting surface resistance to indentation and abrasion.
HEAT AFFECTED ZONE (HAZ)	That portion of the base metal which has not been melted, but whose mechanical properties or microstructures have been altered by the heat of welding or cutting.
HEAT-TREATMENT	All operations in which changes of temperature result in a change in the properties of an alloy.
HOT (RED) SHORTNESS	When steel fractures as a result of mechanical working in a hot state. This type of brittleness is caused by too much sulphur in the steel.
HYDROGEN EMBRITTLEMENT	Atomic hydrogen entry into high strength steel can result in brittle fracture at stresses considerably below the yield strength. The failure may be either intergranular or transgranular and is often very similar to cracking caused by stress corrosion cracking. The susceptibility to attack increases with increasing strength and hardness of steels.
I	
INNER SHIELD WELDING	Semi-automatic method where the arc is struck between parent metal and a tube of filler metal filled with a flux and shield compound which produces the gas shield on melting. The filler metal tube is fed from a spool through the hand-piece automatically which results in a constant arc length.

IN-SERVICE DEFECTS Defects caused by factors such as overloading or fatigue during the service of the component.

INSPECTOR'S QUALIFICATIONS To ensure proper inspection and a degree of standardisation, inspection should be done by qualified personnel. The most commonly accepted diver inspectors qualifications are now the CSWIP 3.1U/3.2U systems.

J

JOINT The junction of members or the edges of members which are to be joined or have been joined.

JUNCTION WELD A weld found at a node where a stub is joined to a can.

L

LAP JOINT A joint between two overlapping materials.

LEG (OF A WELD) The width of a fusion face in a fillet weld.

M

MACROETCHING Treated cross-sections which demonstrate the arrangement of crystals or areas of a weld.

MALLEABILITY A material property allowing permanent extension in any dimension(s) without fracture, by mechanical working. It involves plasticity, but unlike ductility is not so dependent on strength.

MANUAL METAL ARC WELDING (MMAW) Often called MMA or stick welding. The most commonly used method, involving use of consumable rods of filler metal wrapped in flux/shield as the electrode to strike the arc against the parent metal.

METALS A number of elements that are classed as metallic. They possess lustre, opacity, ductility, are good conductors of heat and electricity, give rise to thermo-electric effects and form electro positive ions in solution.

METAL AND INERT GAS arc WELDING (MIG) Metal and argon gas welding (MAG) See "Gas metal WELDING".

MONEL Nickel-copper alloy with good mechanical properties and high resistance to many forms of corrosion. It is used in splash zone of offshore installations.

MPI Magnetic Particle Inspection is an NDT technique used for weld inspection. It is based on flux leakage within a ferrous metal to reveal any discontinuities. (Also see section on "MPI").

MULTI RUN WELD As opposed to a weave method this is a filling method using several runs of straight weld beads resulting in a cap ridged longitudinally.

N

NDT An abbreviation for non-destructive testing, other than visual examination. Any method of evaluation of a subjects integrity without affecting its integrity. (See ACPD, Eddy Current, MPI Radiography, Ultrasonic Inspection and Dye Penetrant).

NODE TRANSITION WELD Transition weld between members at a node. These welds are always full penetration due to the stressed nature of nodes in marine structures.

P

PARENT METAL Two main metal bodies which are joined by welding.

PASS A single progression of a welding or surfacing operation along a joint, weld deposit, or substrate. Also called a run, in welding.

PEENING The mechanical working of metals by means of impact blows. This method is sometimes used to improve the fatigue life of welds. It is also a disadvantageous result of mechanical cleaning methods, as small defects may be peened over.

PERCENTAGE
ELONGATION

This is defined as:

$$\frac{\text{Extension}}{\text{Original Specimen Length}} \times 100$$

PERCENTAGE
REDUCTION OF AREA

This is defined as:

$$\frac{(\text{Original Area} - \text{Final Area})}{(\text{Original Area})} \times 100$$

Where "Area" is the cross-sectional area of the workpiece under examination.

PERFORMANCE
QUALIFICATION

The demonstration of a welder's or welding operators ability to produce welds meeting prescribed standards.

PLASTIC DEFORMATION

A permanent deformation caused by application of a stress greater than the yield stress of the material.

PLASTICITY

The ability of materials to undergo permanent deformation without failure.

POSTHEATING

The application of heat to a weld or weldment subsequent to a welding or cutting operation.

POSTWELD HEAT
TREATMENT

Any heat treatment subsequent to welding.

PREHEATING

The application of heat to the base metal immediately before a welding or cutting operation.

PREPARATION (PREP)

Term given to the shaping of parent metal faces to be welded. In the case of full penetration welds the faces are angled to form a Vee or U which can be filled from the root outwards.

PROOF STRESS

The stress which is just sufficient to produce a permanent elongation equal to a specified percentage (usually 0.1%) of the original gauge length. It is used where materials do not show a well defined yield point (see also "Yield Point").

R

RADIOGRAPHY

An NDT technique used to detect any discontinuity in materials, specifically volumetric flaws such as voids and inclusions. It is based on transmission of 'X' or gamma radiation through the specimen. The discontinuities may either impede or assist the transmission and any variations can be recorded on a photographic plate placed behind the material. (also see section on "Radiography").

RESIDUAL STRESS

Stress remaining in material caused by material cooling after welding, use of force during alignment which is removed after welding or by plastic deformation after over loading.

ROOT (OF A WELD)

The zone on the side of the first run furthest from the welder, where the smallest gap between parent metals exists.

RUN

Welding term used for a pass.

S

SEAM WELD

The longitudinal weld joining the two sides of a rolled plate to form a can.

SHIELDED METAL

ARC WELDING (SMAW)

An arc welding process which produces coalescence of metals by heating then with an arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

SHRINKAGE

Decrease in volume of the metal due to cooling. There are liquid, solidification and solid shrinkage. This can produce shrinkage cavities inside the metal body.

SLAG INCLUSION	Nonmetallic solid material entrapped in weld metal or between weld metal and base metal.
STEEL	An alloy of primarily iron and carbon with additions of other alloying elements (e.g. manganese silicon, nickel and chromium) to obtain the required properties.
STOP START	Where a weld run has been stopped for some reason then restarted.
STRESS	Load carried per unit area of a material.
STRESS HARDENING	Increase in hardness following application of stress above the yield stress. It occurs most often in tiny localised areas of sharp contour change called stress raisers where geometry of the metal magnifies often very low stresses to beyond the elastic limit at the stress raiser which hardens the metal and can lead to brittle failure.
STRINGER BEAD	A type of weld bead made with appreciable weaving motion.
SUBMERGED ARC WELDING (SAW)	An arc welding process which produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and the work. The arc and molten metal are shielded by a blanket of granular, decomposable material on the work. Pressure is not used and filler metal is obtained from the electrode and sometimes from a supplementary source (welding rod, flux, metal granules).
	T
TOE OF WELD/ WELD TOE	The junction between the weld cap and the parent metal.
TOUGHNESS	The ability of a material to absorb energy by plastic deformation before fracture occurs. It is the property which enables a material to resist fracture by impact.

T.T.T. DIAGRAMS/ CURVES	Time - temperature transformation diagram or "S" curves, showing the transformation of austenite at constant subcritical temperatures.
U	
ULTRASONICS/ ULTRASONIC INSPECTION	An NDT technique for detection of defects in materials or measuring wall thickness. (Also see section on "Ultrasonic Inspection").
U.T.S.	Ultimate Tensile Stress. The maximum stress a material can withstand. Complete failure of the material occurs when a stress of this value is applied in tension.
VISUAL INSPECTION	The simplest form of weld inspection, performed by inspector viewing the weld.
W	
WEAVE BEAD	A type of weld bead made with transverse oscillation. (See "Conventional Weave").
WELD	A localized coalescence of metal parts of similar composition produced by heating the materials to suitable temperatures, by friction, electric current, or, most commonly, by an electric current arc and by pressing them together or filling the gap between them with filler metal of similar composition.
WELDABILITY	The capacity of the metal to be welded under the fabrication conditions imposed into a specific, suitably designed structure and to perform satisfactorily in the intended service.
WELD BEAD	A weld deposit resulting from a pass. See "Stringer Bead", "Weave Bead" and "Multi-Run Weld".
WELDING POSITION	The positions in which the joints are welded. e.g. flat, horizontal, horizontal vertical, vertical, overhead.

WELDMENT	An assembly whose constituent parts are joined by welding, or parts which contain weld metal overlay.
WELD METAL	That portion of a weld which has been melted during welding.
WELD WIDTH	The shortest distance between the outer toes of a weld face.
	Y
YIELD POINT	The point between the elastic limit and plastic deformation. This is, sometimes, shown by a drop in the Load (Stress) Vs. Extension (Strain) Curve.
YIELD STRESS	Stress above which a specimen will begin plastic deformation.

4. CONCRETE

Term

Definition

A

ACCELERATED
CURING

The use of an artificially heated moist environment to cure concrete for purposes of increasing early strength. Steam Curing is a common method.

ACCELERATOR

A substance, such as calcium chloride, added in small quantities to plain concrete to hasten hardening.

ADMIXTURES (OR
ADDITIVES)

Substances added, in small quantities, to concrete mix to alter its properties. Commonly air-entrainers, plasticisers, accelerators, retarders.

AGGREGATE

Broken stone, gravel, sand or other similar inert material which forms a substantial part of the concrete mass. See also Coarse Aggregate, Fine Aggregate.

AIR-ENTRAINING

An admixture that incorporates small (1mm or less) air bubbles into the mix to increase workability. Also improves frost resistance.

ALKALI/AGGREGATE
REACTION

Cracking and spalling of concrete caused by reaction between alkalis (always present in cement) and certain (siliceous) aggregates. Not common with aggregates available in UK. Also called cement/aggregate reaction.

ANCHORAGE POINT
(CACHETAGE POINT)

Essential component of post-tensioning equipment, cast into the concrete at the end of a tendon or bundle (group) of tendons. Grips tendon and transfers load from steel to concrete. Offshore, will usually be encased in protective mortar domes.

ANNEALED Process (heating) for improving cold-working properties of steel. Used in manufacture of tying wire.

ANTI-CRACK REINFORCEMENT A close mesh of light steel rods placed just below the surface of concrete to reduce surface cracking.

B

BAR Single item of reinforcement.

BATCH MIXER Mixer which mixes batches of concrete, as opposed to a continuous mixer.

BATCHING PLANT Mechanical equipment for measuring, by weight or volume, quantities of different aggregates required for concrete mix. Usually taken to include associated aggregate storage bins and truck loading equipment.

BAUXITE Aluminium ore used as raw material in high-alumina cement.

BEAM Structural member designed to resist applied loads. Usually horizontal.

BENDING SCHEDULE List of reinforcement required for construction of a reinforced concrete structure, or component of a structure. Shows shape, dimensions and diameters.

BINDER The cement paste within concrete. Serves to "bind" aggregates together.

BLAST-FURNACE CEMENT See Portland Blast-Furnace cement.

BLEEDING Separation of clear water from the cement paste during compaction. Usually a surface condition (not to be confused with laitance), but can take place under reinforcement or larger aggregate particles (see blowholes).

BLEEDING CHANNELS Vertical channels running down the face of concrete due to motion of water within the shutter during compaction.

BLOCKWORK Precast concrete units weighing from 10 to 50 tonnes, used as building blocks to construct breakwaters and quay walls.

BLOCKYARD An area where precast concrete units are poured and allowed to harden before use. Also called casting yard.

BLOWHOLE Void caused by air or water entrapped within the concrete mass, especially at locations of high reinforcement concentration or at built-in items where access restrictions have prevented proper compaction. See also water pocket and bleeding.

BOND Adhesion between concrete and reinforcement. Allows both to act as one in determining the structure's strength characteristics.

BOND LENGTH Length of overlap of end-to end bars, provided to ensure continuity of strength or bond.

C

**CAGE
(REINFORCEMENT)** The assembly of reinforcing bars or mesh within the structure.

CAST-IN-SITU	Concrete poured at the site, directly into the place where it will remain throughout its working life. (ie. distinct from precast concrete, which is cast elsewhere and transported to site when hard). Sometimes called cast-in-place.
CASTING YARD	See Blockyard.
CEMENT	A powder which, mixed with water, binds a mixture of stones and sand into a strong concrete within a few days. Usually portland cement. See also blast furnace cement, high alumina cement and sulphate resisting cement.
CEMENT/AGGREGATE REACTION	See Alkali/Aggregate Reaction
CEMENT GROUT	See Grout.
CEMENT MORTAR	Paste composed of 4 (or fewer) parts of sand to 1 part of cement, with suitable amount of water. See also mortar.
CHAIR	A piece of reinforcing bar bent and placed in such a way that it supports the top layer of reinforcement while itself resting on the bottom layer.
COLD JOINT	See Dry Joint.
COMPACTING (COMPACTION)	The act of expelling air voids from wet concrete to increase density and strength. Usually carried out with mechanical vibrators.
COMPRESSIVE STRENGTH	The resistance, expressed as force per unit area, of concrete at failure in a controlled compression test (Newton/sq. millimetre = N/mm^2).

CONCRETE	A mixture of water, sand, stone and binder (usually Portland Cement) which hardens to a stone-like mass.
CONSTRUCTION JOINT	In reinforced concrete, a joint between successive pours where the first pour has been allowed to set before placing the subsequent pour. Requires special attention to obtain continuity. Reinforcement will be continuous across the joint. Should be vertical or horizontal unless configuration of structure dictates otherwise. In slipformed concrete, construction joints will be fewer, and all will be horizontal.
CONTINUOUS MIXER	A concrete mixer into which stones, sand, cement and water are fed continuously in fixed proportions and from which concrete flows in an interrupted stream.
CONTRACTION JOINT	Discontinuity deliberately introduced in concrete to accommodate shrinkage and thus prevent shrinkage cracks from forming at undesirable places. See also movement joint.
CORNER SPALL	Elongated spall in association with a construction joint, expansion joint, etc.
COVER	Thickness of concrete between any reinforcing rod and the nearest external face of the concrete. Commonly 25mm to 75mm. (75mm is typically offshore value).
COVER METER	Non-Destructive Testing instrument for locating steel within concrete up to a maximum of approximately 70 mm from the surface of the concrete.
CRACK	Surface discontinuity caused by excessive tensile, shear or torsional loads. Tensile cracks will normally occur at approx. 90° to the long axis of a beam. Shear cracks in beam or wall will normally be at approx. 45° to the horizontal, on the vertical faces. Torsional cracks in a beam will also be at 45° , but may occur on any, or all, faces.

CRACK INDUCER	Linear insert, in the form of a timber batten, etc. cast into the surface of a concrete slab to introduce a weak point for controlled positioning of possible cracks.
CRACKING	Cracking is always expected in reinforced concrete, since concrete has low tensile strength. Cracks due to hardening shrinkage can be controlled (see contraction joint, crack inducer). Cracks will also occur on the stretched face of a beam or slab under load, but sufficient steel reinforcement will normally be provided near that face to make such cracks invisible to the naked eye.
CRAZING	Pattern of fine cracks on surface of concrete. Usually the result of inadequate curing. See also pattern cracking.
CRUSHING STRENGTH	The load at which concrete fails in compression. Established by crushing samples (usually cubes) in the laboratory. See also compressive strength.
CURING	Keeping concrete damp for the first week to one month of its life so that cement is always provided with enough water to harden. Improves final strength and reduces surface cracking. Usually water curing with damp hessian sheets.
CURING COMPOUND	A liquid (usually tar based) sprayed over fresh concrete to prevent drying out (cracking) and improve strength. See also Curing Membrane (2).
CURING MEMBRANE (1)	Polythene sheet, building paper or other impervious material laid over fresh concrete to prevent drying out.
CURING MEMBRANE (2)	Solidified coating of curing compound, originally applied in liquid form (sprayed).

CURING PERIOD The amount of time during which concrete must be kept damp after casting. In Britain, usually one week.

D

DEFORMED BARS Steel reinforcement having a pattern of ribs to improve bond with surrounding concrete.

DELAMINATION Spall covering a large area of the concrete face, usually due to internal pressure. Also called sheet spall.

DISINTEGRATION General deterioration of concrete into small fragments with considerable loss of material. May be advanced stage of alkali/aggregate reaction.

DISTRIBUTION BARS
(DISTRIBUTION
REINFORCEMENT/
STEEL) Subsidiary reinforcement placed at 90° to main bars to hold it in place during concreting and to spread concentrated loads over a larger area of a slab.

DRAG MARKS Vertical marks on the face of slipformed concrete, caused by the upward movement of the slipform over unset concrete.

DRY JOINT Improperly formed joint between successive pours due to inadequate surface preparation (wetting) of first pour. Second pour loses water into the already hardened concrete of the first pour. Also called cold joint.

E

EFFLORESCENCE Formation of salts, usually white, on the surface of the concrete. The salts come from within the concrete mass.

ENCrustATION (INCRUSTATION)	Deposits of lime leached from the concrete to form a crust on the surface.
END BLOCK	The concrete at the end of a prestressing tendon or bundle, containing the anchorage and reinforced to prevent bursting under load.
EPOXY COATING	Covering of epoxy resin provided as seal and protection to mortar dome at anchorage point.
EROSION	Wearing away of the concrete caused by the abrasive action of moving fluids or by solid particles suspended in fluids. (eg. Tidal or Wave action). A very long-term effect (assuming concrete quality is good).
EXPANSION JOINT	A discontinuity in both concrete and reinforcement, deliberately introduced, at say 6m intervals, to accommodate both expansion and contraction of the concrete. Usually filled with compressible material and sealed with highly adhesive, flexible mastic sealant. See also Movement Joint, Contraction Joint.
EXUDATION	Liquid or viscous gel-like material discharged onto the surface through a pore or crack in the concrete, probably due to alkaline aggregate.

F

FABRIC	Prefabricated reinforced mesh, usually of welded steel and rectangular or square pattern. May have larger diameter main rods in one direction with smaller diameter rods at 90°.
FALSEWORK	Temporary support for formwork during concrete placing and hardening.

FINE AGGREGATE Aggregate less than 5mm in particle size, usually sand or crushed stone.

FLASH SET Unusual and inconveniently rapid setting of concrete.

FLAT SLAB A reinforced concrete slab which spans in two directions at 90° to one another. Its length will usually be less than twice its width and preferably equal to it (ie. square slab).

FONDU See High Alimina Cement.

FORM A piece of formwork. See also Shutter(ing).

FORMWORK Temporary boarding or sheeting (and all supporting framework) erected to contain wet concrete during placing and for the first few days of hardening. Sets the shape, dimensions and surface texture of the finished concrete. See also Shuttering.

FREEZE/THAW DAMAGE Disruption of concrete surface (usually the cement binder) caused by the expansion of freezing moisture within the concrete. Affects porous concretes and the cycle of freeze/thaw/freeze allows the condition to advance into the concrete.

G

GRADED AGGREGATE Aggregate containing selected proportions of different particle sizes, chosen to form a concrete of maximum density.

GRADING (OF AGGREGATE) The proportions of different sized aggregate particles in concrete, usually chosen to produce concrete of maximum density or to enhance workability.

GROUT (NOUN) Fluid or semi-fluid cement slurry used as filling material (eg. in tendon ducts). Improves bond and reduces corrosion.

GROUT (Verb) To fill with grout.

GROUT LOSS Leakage of cement paste through inadequately sealed formwork. Can result in honeycombing, usually at edges, corners or construction joints.

GUNITÉ See sprayed concrete. (Sometimes called shotcrete esp. in USA).

H

HAIRLINE CRACKING Very fine, unconnected cracking in random locations.

HARDENING Increase in strength of concrete with age. Continues at ever-decreasing rate for very long period.

HEALING The closing up and disappearance of breaks or cracks in concrete when the parts are kept moist and in contact.

HIGH ALUMINA CEMENT Cement having greater alumina content than ordinary portland cement. Can only be used in thin layers due to high heat on hardening. Used for pipe weight coatings and has typical dark appearance. Has good acid and sulphate resistance. Sometimes called fondu.

HIGH TENSILE (HIGH YIELD STEEL) High carbon/manganese steel, stronger than mild (approx. 1.5 times stronger). Usually ribbed or twisted (now uncommon) to improve bond. Reinforcement in offshore structures will be High Tensile Steel.

HOG Upward bending of a beam under load, usually in the middle.

HONEYCOMBING Obvious localised roughness of concrete face, possibly extending to the interior of the mass, resulting from failure of the fine aggregate to fill the voids between the coarse aggregate particles. Such concrete is weak and should be replaced at time of construction. See also Grout Loss and Segregation.

HYDRATION The setting process of concrete. A chemical reaction requiring the addition of water.

I

IMMERSION VIBRATOR See Poker

INJECTION TUBE Tube, at anchorage point, for injection of protective grout into tendon duct. Usually cut off flush.

J

JOINT SPALL Elongated spall in association with a construction joint, expansion joint, etc.

L

LAITANCE Condition of over-trowelled concrete face whereby a small layer a grout/mortar is drawn to the surface. This is considerably weaker than the concrete mass and will often break away under light loading.

LEACHING The removal of salts or other substances from the concrete due to the passage of water through it.

LIFT When pouring a concrete wall or column, the height shuttered at one time. May comprise a single pour or several pours, dependent on magnitude of lift.

LINKS See Stirrups.

M

MAIN BARS (MAIN REINFORCEMENT)	Reinforcement provided to resist expected loads in a beam, slab or wall.
MASS CONCRETE	Concrete without reinforcement. See also Plain Concrete.
MILD STEEL (REINFORCEMENT)	Low-carbon content steel for low load situations. Usually plain round section rods.
MISALIGNMENT	Obvious "step" at junction of successive lifts, often accompanied by evidence of grout loss. Caused by failure to clamp shutter for second lift tight against concrete of previous lift.
MIX	The proportions of a batch of concrete.
MIX DESIGN	The selection and proportioning of aggregates, cement and water in the concrete. Mixer may be designed previously for strength but also for low cracking characteristics, low heat evolution during hardening or workability.
MORTAR	See Cement Mortar
MOULD	A temporary structure built to hold concrete while it is setting. Usually restricted to precast concrete. For site concrete the term formwork is more usual.
MOULD OIL	Liquid preparation on to face of shuttering to facilitate separation from hardened concrete. Other benefits are improved finish on concrete and demobility (for re-use) of shutter. Can cause discolouration of concrete. Also called release agent.

MOVEMENT JOINT General term of manufactured discontinuity in concrete, for whatever purpose - see also Expansion Joint, Contraction Joint.

P

PASSIVATION Steel reinforcement having a pattern of ribs to improve bond with surrounding concrete.

PATTERN CRACKING Similar to crazing. Pattern of intersecting cracks on the surface of the concrete due to differential shrinkage.

PITCH Spacing of bars, distance between centre lines of adjacent parallel bars.

PLACING The pouring into position of wet concrete, particularly in situ (see cast in situ).

PLAIN CONCRETE Concrete not having reinforcement to carry loads or bending forces; but with light steel (generally about 0.6% of the total volume of the concrete) to reduce shrinkage cracking. Mass concrete has less steel and perhaps none.

PLASTICISER A concrete admixture which can increase workability while retaining a low water/cement ratio and thus increasing strength.

POKER Device for aiding compaction by vibration. Poker is immersed in wet concrete for a specified period, and at regularly spaced locations to obtain uniform result. Also called immersion vibrator.

POPOUT Small, generally circular portions of concrete which break away from the concrete surface. Superficially similar to minor spalls, but will be conical in shape and randomly distributed over the surface.

PORTLAND BLAST-FURNANCE CEMENT	Cement with up to 65% crushed blast-furnace slag. Used for specialised applications and increasing sulphate resistance.
PORTLAND CEMENT	Basic cement produce by heating slurry of crushed chalk (or limestone) and clay to produce clinker, which is then finely ground. Portland Cement also forms the basis of most specialised cements.
POST-TENSIONING	Prestressing of concrete by cables jacked up to full load after concrete beam, etc. has been cast. Cables are contained within tubular ducts which are filled with grout on completion. Common in certain elements of offshore structures.
POUR	An individual, continuous placement of concrete. Large structural components will normally consist of a number of pours. The magnitude of a pour is determined by available concrete mixing capacity, mould/shutter size or other practical limitation. See also lift.
PRECASTING (PRECAST CONCRETE)	Fabrication of finite structural units before lifting into position. Gives good quality control and is useful (and economical) for production of repetitive identical components.
PRESTRESSED CONCRETE	Concrete in which cracking and tensile forces are eliminated (or greatly reduced) by compressing it with stretched internal cables or rods. (See also tendons). Two main methods are pre-tensioning and post-tensioning.
PRE-TENSIONING	Prestressing of concrete members by tensioned wires embedded during construction. Uncommon offshore.
RAPID-HARDENING CEMENT	Cement more finely ground than ordinary portland cement and thus hardens more quickly.

R

R.C. Abbreviation of reinforced concrete (in common use).

REBOUND HAMMER A quick testing method for estimating concrete strength to within $\pm 3N/mm^2$. Also known as a Schmidt Hammer.

REINFORCED CONCRETE (R.C.) Concrete containing reinforcement consisting of steel rods or mesh. The steel takes all of the tensile stresses, while the concrete provides compressive strength. Commonly abbreviated to R.C.

REINFORCEMENT Rods or mesh embedded in concrete to strengthen it. For purposes of offshore structures, the rods/mesh will be of steel.

RELEASE AGENT See Mould Oil.

RESINS (EPOXY) Components with high adhesion and durability often used for surface repairs or where special protection is required against ingress of sea-water (eg. at points prestressing anchorage). Special low-viscosity resins are used for crack-sealing.

S

SAG Downward bending of a beam under load, usually in the middle.

SANDPOCKETS Obvious sandy sections having little or no cement content, due to inadequate mixing.

SCALING Local or general flaking of the concrete surface layer, sometimes with loss of aggregate particles.

SCHMIDT HAMMER See Rebound Hammer

SEGREGATION	Separation of the constituents of the concrete mix such that the heavier coarse aggregate sinks to the bottom. Caused by over-vibration, or dropping the wet mix into the shuttering from an excessive height. Can cause honeycombing.
SHEET SPALL	See Delamination.
SHOTCRETE	See Guniting
SHRINKAGE	Contraction of concrete during early stages of hardening. Important in prestressed concrete as it will produce some loss of prestress. Can cause cracking of the surface.
SHUTTER(ING)	Specifically, that part of the formwork, usually boarding or sheeting, which is in contact with the concrete (but often used to describe the complete formwork assembly - see Formwork). May be steel, plywood, rough timber, etc. - depending on required standard of finish.
SLAB	Large area of (relatively) thin reinforced concrete, spanning between beams or supporting walls. Usually horizontal. See Wall.
SLIPFORMING	Technique for continuous casting of repetitive lifts of reinforced concrete. The prefabricated shutter or slipform is jacked up slowly and continuously at a rate compatible with the hardening of the concrete. Originally developed for concrete road slabs.

SPACER Device fixed to the outer layer of reinforcement to distance the reinforcement from the face of the formwork, thus ensuring correct minimum cover of concrete (ie. size of spacer = required value of cover). Spacers are permanently cast into the concrete and may be made on site (small precast concrete blocks with tying wires) or proprietary (plastic mouldings clipped to reinforcement). May be visible on surface of concrete.

SPACING Distance between centre lines of adjacent, parallel, reinforcing rods.

SPALLING The breaking away of fragments of the surface concrete in service due to weather, loading, impact or internal pressure. Usually occurs as corner spalls or joint spalls and can be classed as Minor (less than 150mm across and 20mm deep) or Major (up to 600mm across by 75mm deep). See also delamination.

SPRAYED CONCRETE Cement/sand mortar applied by compressed air ejector. Very dense, high strength concrete used for pipeline weight coating. See also gunite and shotcrete.

STARTER BAR A reinforcement bar projecting through a construction joint (by a length usually equivalent to at least 45 times the bar diameter). Starters are used, as the name suggests, to start construction of the reinforcement cage beyond the joint.

STEAM CURING Accelerated curing of precast units in a steam area.

STEEL Commonly used term to describe all classes of reinforcement.

STEELFIXER Skilled operative who cuts and bends reinforcement to shape and who fixes it in position prior to concreting.

STIRRUP	Bar bent to rectangular shape to resist shear or simply to retain main bars in position.
STONE	Commonly used term for coarse aggregate.
SULPHATE ATTACK	Chemical attack on the cement binder in concrete. Causes softening or expansion. More common on land (in sulphate bearing groundwaters) than in marine location.
SULPHATE-REDUCING BACTERIA	Bacteria which, by production of hydrogen sulphides and/or sulphuric acids, can attack the concrete surface.
SULPHATE RESISTING CEMENT	Specially formulated cement, less easily attacked by sulphates in soil or sea-water.
SUPERSULPHATED CEMENT	A cement made mainly from blast-furnace slag. Resists sulphate attack even more than sulphate resisting cement.
T	
TENDON	Common collective term describing prestressing bar, cable, rope, strand or wire. Usually provided in bundles.
TENDON DUCT	Tube through which tendons or bundles of tendons pass within the concrete member. May be spirally wound steel.
TENSION FACE	That face of a beam or slab which, under loading, is placed in a state of tension and therefore requires reinforcement. Also the face most likely to exhibit cracking.
TEST CUBE	A 100mm or 150mm sample cube of concrete used for testing concrete strength in the laboratory. Usually tested at ages of 7 days and 28 days.

TIE-BOLT (TIES) Used with vertical shuttering. Tie-bolts at regular spacings pass completely through the concrete and hold the shuttering together to increase rigidity and thus prevent deformation due to pressure of wet concrete. Withdrawn on removal of the shuttering, and the bolt holes filled with mortar.

TREMIE A sheet metal hopper with a pipe leading out of the bottom, used for placing concrete under water. The foot of the pipe must always be kept within the wet concrete to prevent segregation and dilution of the concrete by the surrounding water.

28-DAY STRENGTH The established standard for assessing quality and future performance of concrete. Standard sized cubes of concrete are made at the time of construction and tested to failure 28 days later in the laboratory by crushing. The applied load at failure, computed against cube size, gives the compressive strength at 28 days. Failure to achieve prescribed strength criteria may lead to condemnation of the appropriate part of the structure.

TYING WIRE Fine malleable wire, usually annealed, used by steel-fixers to tie the reinforcement bars together to form cage. Also used to secure concrete spacers to reinforcing bars.

V

VIBRATION See Compacting.

VOIDS Spaces within the concrete mass, filled with air, water or both.

W

WALL Vertical or inclined reinforced concrete slab.

WATER BAR A jointing strip, usually of PVC, (but may also be galvanised steel, lead, copper, rubber or bituminous material) inserted into concrete at a joint to exclude water after the concrete has hardened. Rigid materials may be used for construction joints, but proprietary sections of flexible material must be used for movement joints.

WATER/CEMENT RATIO The weight of water divided by the weight of cement in concrete or mortar. The lower the water/cement ratio the stronger the concrete. The higher the water/cement ratio the greater the workability. The ratio is usually chosen to provide an acceptable compromise between strength and workability.

WATER POCKET See Blowhole.

WEIGHT COATING Sprayed concrete coating applied to pipelines (onshore) prior to placing. Provides (a) protection against damage and (b) negative buoyancy, to ensure pipeline will remain on seabed, even when full of air.

WET MIX Concrete mix with too much water.

WORKABILITY The degree of ease with which wet concrete can be placed. Determined by grading of aggregate and water/cement ratio.

