OPERATION AND SAFE MANAGEMENT OF FLOATING DOCKS

D M Westmore, Clark & Standfield Limited, UK

SUMMARY

This paper looks at the various features of a floating dock and it's associated control systems in regard to the safe operation and management of the dock. The strength and stability aspects are examined as well as operational limitations due to loadings, freeboard, and environmental hazards. The documentation required to establish the safe operation and management of the dock is also reviewed.

1. INTRODUCTION

There are many floating docks worldwide operated by ship repairers, shipbuilders, navies and ports. They vary in lifting capacity from less than 500 tonnes to over 100,000 tonnes enabling them to lift all types of vessels from workboats to VLCCs. The majority of floating docks are used for docking and undocking but in some cases they are also used for shore transfer. Whilst naval floating docks are often the subject of rigorous inspection and requirements, particularly where docking nuclear submarines are involved, this is often not the case with commercial docks.

With docks falling between a marine structure and a civil structure, and often considered as part of a shipyard building infrastructure, there is often little in the way of regulatory requirements specific to floating docks to ensure that operators safely operate and manage their docks.

Dock operators do not always have sufficient knowledge of dock design to understand their dock's limitations. Furthermore, as many docks are long-lived and/or second-hand there is often a lack of associated design data limiting the extent to which an operator can investigate a dock's limitations. It is therefore not uncommon for lift's to be carried out purely on the basis of checking the docking weight against the maximum lift capacity rather than checking stability, block loading etc. Docks are fairly forgiving structures and can, and have accommodated much abuse but such unawareness occasionally leads to accidents. In today's environment of health and safety and the increasing variety of ship types which may not have been considered when the dock was designed, it is much more important that owners and operators consider the operation and management of their docks and understand their limitations.

This paper aims to address the various issues relating to these problems. It is primarily aimed at steel floating docks although many of the comments are applicable to timber docks, concrete docks or composite docks.

2. FLOATING DOCK

The modern floating dock has its origins in the late 19th Century. Although there were a number of novel types to enable self-docking, there are today principally two types: the box dock and the sectional pontoon (Rennie). The latter is self-docking. There has been little change to docks over the years except to the machinery and in particular control and monitoring systems.

The dock generally consists of a U shaped box structure formed by a pontoon on which a sidewall is mounted on each side. The structure consists of a number of ballast tanks ranging from about 9 for small docks to about 40 for large docks. A typical floating dock is illustrated in Figure 1. The dock is sunk by free flooding and raised by pumping. Control is achieved by manipulating the compartment valves. The control centre for the dock is normally placed either at the centre of the dock or at the end (opposite the entrance end) on one sidewall.

In order to safely control and operate a floating dock, operators need to ensure that their dock is provided with adequate control and monitoring systems. These should ensure that:

- the dock can be kept within safe limits
- the dock can be operated correctly
- system failure can be identified and safely handled

3. DOCK CONTROL & MONITORING SYSTEMS

3.1 LONGITUDINAL DEFLECTION MONITORING SYSTEM

Docks are designed for either level ballasting or differential ballasting. For small docks, where longitudinal strength is not a significant factor, level ballasting is commonly used in which ballast is adjusted to control trim, heel and draft whereas for the larger docks differential ballasting is used where ballast levels are adjusted to control trim, heel, draught and longitudinal deflection.

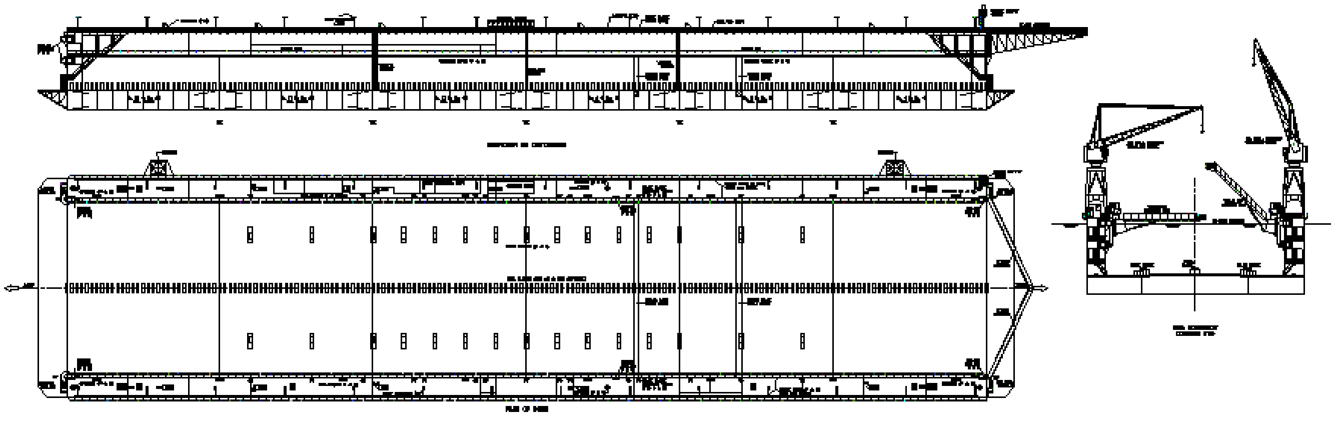

Figure 1: Example of a 20,000 TLC Box Type Floating Dock

Longitudinal deflections result from the longitudinal bending moments occurring in the dock due to the distribution of buoyancy, dock self weight, ballast and ship weight. Generally, the self-weight of the dock and buoyancy are fairly evenly distributed so that the principal cause of the longitudinal bending moments is the ship weight and ballast distribution.

As the longitudinal bending moments increase, the deflection tends towards a curve. The dock operator, by observing the deflections, will try to minimise deflections during a docking evolution to reduce stresses in the dock. Where the blocking length of a ship is relatively large in relation to the dock length, large deflections are undesirable as they increase the blocking loads towards the ends of the blocking length when the dock is sagging. In addition, some of the longitudinal bending moments are shared with the ship. Unexpected deflections are a guide to problems resulting from a bad lack of fit between the blocks and the ship or problems in ballasting or deballasting dock compartments.

There are a number of deflection systems that are calibrated to show deflection from the minimum bending moment condition for which the keel blocks are levelled. Examples are:

- Hydraulic Type: The hydraulic system consists of a number of vertical tubes placed at intervals over the length of the dock and interlinked by a common pipe. The tubes are provided with sensors that monitor the levels. From this the dock deflection and trim can be monitored. These systems are not dependent on the control house position.

- Draught: By monitoring the drafts of the dock deflections of the structure can be determined. However, these must be calibrated to show deflection from the zero bending moment conditions and not the dock's underside of keel deflection.

- Optical: There are currently two types of optical system. For centrally placed control houses, the telescope simultaneously focuses on markers placed at each end of the dock wall with the image of one end marker being superimposed on the other. For control houses mounted at the end of the dock the telescope is focused on a marker at the other end of the sidewall. Intermediate markers then show the deflection of the dock relative to the end marker.

Strain gauges are another means of measuring bending moment in the dock but are not common and do not facilitate deflection monitoring.

Some classification societies require more than one type of deflection monitoring system for large docks. i.e. >40,000 tonnes lifting capacity (TLC). For small docks, typically in the order of 1000 TLC, the deflection system serves little purpose, as the deflections are too small to be suitably monitored and due to the inability to load the dock in such a manner that longitudinal strength can be exceeded. Concrete docks have little deflection and therefore rigorous use of pumping plans is required to avoid overstressing the structure. Composite docks with steel sidewalls and concrete pontoons the dock will deflect in similar fashion to all steel docks.

To avoid accidentally exceeding allowable deflections, an alarm system should be provided to give the operator warning that he approaches the allowable limits.

3.2 DRAUGHT

All docks should be fitted with draught gauges measuring the water levels at each end of the dock. These can also be used, if fitted at each corner and each side at amidships, for measuring trim, heel and deflection. Draught gauges should be clearly marked to show the maximum deep sink waterline and the minimum operating pontoon freeboard. They should also be capable of showing the water depth over the keel blocks.

Draught marks should also be provided within the dock well to assist personnel with the docking phase.

3.3 TRIM AND HEEL INDICATORS

Trim and heel indicators are essential for keeping the dock level during docking evolutions. They need to measure a very small range of 1 to 2 degrees of heel and 1 degrees of trim. They are often of the form of spirit level (bubble) or pendulum type. Throughout the lifting of a vessel the dock should be kept upright at all times. This is particularly critical during immersion of the pontoon as any trim or heel is considerably magnified with the large change in the water plane area.

Heel and trim can also be measured from the draught gauges or from the longitudinal deflection indicator system when of the hydraulic type.

3.4 TANK LEVEL GAUGES

During docking/undocking evolutions all ballast tanks require a means of monitoring their contents in order to check for unusual ballast distributions that may indicate:

- a poor block fit (i.e. ballast distribution correcting an irregular load distribution caused by the block fit)
- pumping problems, e.g. pump failure
- valve problems, e.g. valves failing to open or close
- leakage from poor fitting manhole covers, corroded pipes, loss of air cushion at deep sink, etc.

The ballast levels are usually compared against the guidance levels in the pumping plan ballast distribution to ensure that the correct ballast distributions are maintained and therefore, particularly with large vessels (relative to the dock's capacity), that localised overloading will not occur, e.g. transverse strength

Figure 2: Valve Control Console & Tank Gauges

There are a number of different types of ballast monitoring system which either measure the level directly (e.g. ultrasonic) or indirectly via pressure. All systems will measure the ballast levels until the air cushions start to form as the dock approaches the deep sink condition after which pressure sensors will measure the depth of water plus the additional head of air cushion pressure. The latter type are preferred as they can be used to give the differential hydrostatic head acting on the ballast tank boundary bulkheads for all conditions including at deep sink. They will also show loss of air cushion pressure after the tank valves are closed. Pressure sensors should show when the reading incorporates the effects of the air cushion.

Ballast Tank gauges should be laid out in the same orientation as the dock to ensure quick correlation by the dockmaster between tank and valves relative to the dock. Reference Figure 2.

During the lay period, the ballast tanks require regular monitoring to check for leakage.

3.5 PUMP CONTROL SYSTEMS

Pumps are normally only required to raise the floating dock; sinking being carried out by flooding. When raising a dock it is usual practise to run the pumps continuously whilst valves connecting to the tanks are opened and closed as required. Pumps can either be of constant or variable speed. Slow speed is sometimes of benefit when a ballast tank is nearing minimum levels as it ensures that loss of suction does not occur too early thus minimising the residual ballast levels (i.e. water which cannot be removed by normal pumping). This may occur when lifting vessels near to the limits of a dock's capacity.

Pumping of any dock too fast is undesirable as heel, trims and deflection can occur too quickly for the operator to respond effectively. The majority of docks have lifting times of 1 to 3 hours depending on the dock size and this has been found to be manageable.

It is important that the operator knows the pumps are working and this is usually in the form of ammeter readings in the control house. Other means such as measurement of suction/discharge pressures or flow meters can be provided. These help to identify such problems as loss of suction (when nearing residual ballast levels), impeller failure or shaft failure.

3.6 VALVE CONTROL GEAR

Docks operate generally by continuously running the pumps and then opening and closing the compartment valves to control trim, heel and deflection. Valve controls should be laid out in the same format as the tanks with clear indication whether open or closed. The dockmaster should be able, at a glance, to visualise which compartments are open or closed. This makes it easier for the dockmaster to decide which compartments should be manipulated to accommodate changes in trim, heel and deflection.

In the event of a power failure or in the case of hydraulic/pneumatic loss of pressure, all valves should immediately fail safe, although this is not always the case in some docks. It should be noted that in a large dock it takes sometime to close all valves manually during which undesirable trims, heel or deflection could occur.

Some docks are also provided with facilities to enable further valve manipulation during a power loss. This can involve manual arrangements and/or air reservoirs to permit valve manipulation (usually in the order of two complete cycles of all compartment valves). This permits adjustment to the trim, heel or deflection of the dock to bring to, or maintain, a safe condition before restoration of power.

There should generally be at least two valves between the tank compartment and the sea to avoid leakage problems and to facilitate compartment valve repair. In some naval docks this is supplemented by a flap valve in way of the hull inlet and hull discharge.

3.7 DEWATERING PUMPS

The majority of floating docks use centrifugal pumps submerged in a tank compartment. Motors mounted on the safety deck drive the pumps via vertical shafting, see Figure 3. All docks should be fitted with more than one dewatering pump and the system arranged that in the event of pump failure an adjacent pump can be cross connected to assist. This is particularly important as in most docks the dewatering system is submerged within the tanks and repairs can only carried out when the compartment has been pumped out. In very small docks it may be suitable to use a pump from the fire and wash down system.

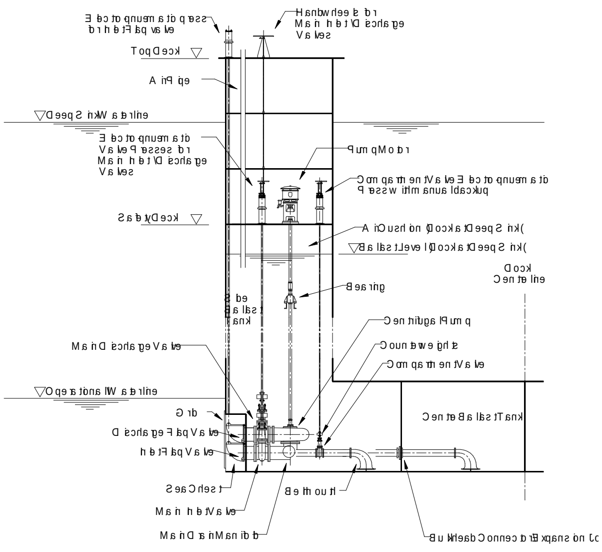

Figure 3: Typical Section Sidewall for Naval Dock

Another important feature is that a non-return valve or flap valve should be fitted to the seaward side of the pump. In the event of the pump stopping whether due to normal operations or power failure, there should be no back flooding which may either flood the compartments or drive the pump motor as a generator.

3.8 ELECTRICAL POWER

All docks should be provided with alternative power sources. This may be in the form of two shore feeders (primary and standby), shore feeder and onboard generator, or onboard generators. Thus any failure of supply during docking operations, the dock can continue and thus avoid problems of the dock being in a partial state of lift. The standby power should be sufficient to enable operation of all valves, lighting, communications, fire systems, and a proportion of the dewatering pumps. Standby generators should have sufficient capacity to enable a complete docking evolution to be carried out.

4. OPERATION

4.1 DEEP SINK

The deep sink condition represents the dock at it’s maximum sinkage which depends on the amount of ballast that can be admitted to the tanks. Due to the large submerged mass of the dock relative to its small water plane area at deep sink, the cumulative effects of dimensional tolerances, scantling tolerances, trapped air, etc relative to the small water plane area make it difficult to determine the exact ballast levels at the design stage. For this reason and also to cater for future weight changes to the dock, docks are usually provided with more capacity than needed.

Extending the air pipes into the tanks results in the trapping of air at the top of the tanks when the tanks are full. This air is often known as the air cushion and its size will affect the amount of ballast water in the tank. The size of the air cushion is dependent on the pipe lengths, which are adjusted from trial results. These are set so that the dock cannot be sunk below the maximum waterline for which it was designed and will achieve level floatation with minimal longitudinal deflection at deep sink.

The safety deck, which forms the crown of the sidewall ballast tanks will usually have a number of penetrations for valve control reach rods, pump shafts and cable glands. It is no longer acceptable practise to provide manholes in the safety deck unless these are trunked to the top deck although such features may be found in some older docks. These penetrations can be a source of leakage for the air cushion. Therefore regular checks by means of a deep sink trial should be carried out to check their integrity and at the same time adjust the air pipes if there have been any changes to the docks weight, for example, change of cranes.

4.2 STABILITY

There are, in general, no statutory requirements regarding the minimum stability applicable to a floating dock. Whilst the stability of a dock is usually very large when at operating freeboard, the stability can become vary small during the transitional phase from deep sink to the pontoon emerging. The minimum stability usually occurs when the waterline is between the top of dock blocks and the top of pontoon. The standard of stability commonly accepted for this phase is for a transverse metacentric height (GMT) ranging from 1.0 to 1.5m whilst some ship owners may require a higher value in the order of 3.0m GMT. The choice of stability standard requires to be considered for various reasons:

- Small GMT can make it difficult to maintain the dock level during lifting.
- It is often the case that the weight and centre of docked vessels is not accurately known at the time of docking and a higher standard ensures some margin of safety.
- Small GMT can result in sensitivity to wind conditions.
- Estimated ballast levels from the docking plan are only guidance and in actual operation the levels may vary slightly. The standard of stability therefore needs to incorporate some allowance for this.

Some authorities and classification societies have stability standards but there is currently no unified approach. In practice, a GMT of 1.5m is usually considered sufficient.

4.3 FREEBOARD

4.3 (a) Deep Sink Freeboard

A number of classification societies and authorities set this value at not less than 1.0m although in larger docks this is probably better set at about 2 metres minimum. The dock should be arranged that it is not possible to sink below this value.

4.3 (b) Operational Freeboard

The operational freeboard is measured from the top of pontoon deck plating. There is no uniform approach by classification societies and authorities but typically it is in the order of 75mm to 450mm over the pontoon length. In practise, other factors need to be considered, for example, movement of cranes or height of waves. Some docks are also trimmed in the operating position to assist in the drainage of water on the pontoon deck from hydro blasting etc. to collection tanks.

When at operating freeboard there should be strict limitations on the opening of pontoon deck manholes as any flooding could result in loss of freeboard resulting in a large change in stability of the dock system.

4.4 STRENGTH

4.4 (a) Weight Distribution

The approach to strength varies between classification societies. For some, a design weight curve is defined, whilst for others the characteristics are defined by limiting dock deflection and the block loading. Regardless of the design approach, a dock operator needs to establish the weight distribution of the vessel on the blocks to check the adequacy of the dock. Due to the complex nature of ship's structures and innumerable variations in the degree of fit between the ship and dock it is usually sufficient to treat the weight distribution as trapezoidal with weight and centre matching that of the ship and the length equal to the blocking length, see Figure 4. For unusual weight distributions, large overhangs etc. it may be necessary to investigate the loading in a more detailed manner.

4.4 (b) Longitudinal Strength

Although docks can often accept fairly large deflections before reaching stress limits, such deflection can result in high block loads and large deflections of the ship, which in some cases may be unacceptable. It is therefore necessary to ensure that deflections are minimised at all times.

In the past it was usual to try and match the weight load with the required lift over a tank section. This approach has limitations as the ends of the blocking length usually do not match the tank boundaries and affects of trim also need to be considered. With the advent of computers it is now relatively straightforward to determine a ballast distribution to minimise deflection whilst setting constraints for tank levels, trim, heel, draft, transverse strength, etc.

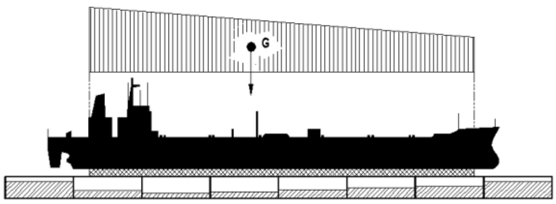

Figure 4: Idealised Weight Distribution and Differential Ballasting

The ship weight distribution less any buoyancy effects is used to provide guidance on the required ballast distribution at different phases of lift for the docking plan. Unusual variations of actual values from the guidance are a good indicator of problems. The ballast distribution guide also enables an estimate of the minimum bending moment that can be achieved demonstrating that the dock can lift within the longitudinal strength limits and that longitudinal deflections can be minimised.

With the loading regime identified, transverse strength, bulkhead loadings, keel block loadings and bilge block loadings can be determined to ensure that there are no particular problems.

4.4 (c) Transverse Strength

Modern docks tend to be much wider than of old due to greater beam to length ratios in modern ships and, for smaller docks, the emergence of multi-hulled vessels, which gives rise to greater transverse bending moments. This appears to be an area rarely considered by dock operators who in the past have often relied on the designer enveloping all scenarios. It is therefore of far greater importance to examine the transverse strength of docks today. The designer will attempt to envelope all normal variations but with the great variety of ships, possible ballast distributions and docking configurations, it is important that ships, particularly the larger ones in relation to the docks lift capacity, be checked on an individual basis. For example, in trying to minimise longitudinal loadings, the resulting ballast distribution could increase the transverse loading and vice versa.

Since docks may have in the order of some 50 to 80 transverse frames it is not normally considered practical to place stress or deflection measurement devices for all frames and therefore reliance is generally made on calculation.

4.4 (d) Local Strength

The dock operator requires to have sufficient information on the local strength in order to know the limitation on differential ballast levels between compartments or the loading of the pontoon deck. In the case of the pontoon deck, the operator needs information to enable the positioning of keel and bilge blocks to accommodate different ships. The maximum pontoon deck loading clear of the blocking is required for accommodating staging, vehicles or temporary support structures.

4.5 EMERGENCY DOCKINGS.

Docks can be heeled and trimmed to match that of a damaged vessel. Where the extent of damage is not fully defined they can be used to provide partial support until a more detailed assessment has been made. In addition to the normal investigations the following needs to be investigated:

- extent of any bottom damage and affect on the blocking arrangements and loading. Bottom damage may require damaged steelwork to be removed to avoid blocking problems.
- Stability aspects due to flooded compartments and the rate that these compartments will empty during the lifting of the vessel.
- Strength of vessel in way of block supports and also overall strength.

The guiding principle should be that if the safety of the dock is compromised, the docking operation should not be undertaken so as not to risk the dock's use for other vessels.

5. HAZARDS

5.1 COLLISION

The effects of ship collision need to be examined. When the dock is down, protection of the sidewall end spaces at the entrance end needs to be considered in regard to collision from the docking ship. This can be overcome by fendering and in many docks protection is provided by an open steelwork construction. When the dock is at operating freeboard the end aprons normally protect the ends of the dock. Sides of docks are more vulnerable although location of dock or its orientation in regard to traffic can minimise collision effects.

5.2 FIRE

Operators need to address the effects of fire, particularly on board a docked ship. Pumping of water onto a vessel may generate problems with block loads and dock strength whilst stability may be affected should the fire occur high in a vessel superstructure. Options are either to remove the vessel or leave the vessel on the dock. The option to remove a vessel may be constrained by time, for example if left too long, the build up of fire water in the vessel may make undocking dangerous in regard to stability for both the ship and the dock. Operators need to consider what the limiting factors are, particularly in relation to large vessels in order to make appropriate decisions in such an event.

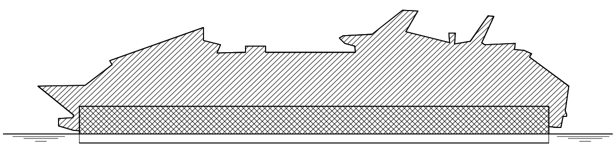

Figure 5: Lateral Wind Area

5.3 WIND

Wind loads affect dock heeling and mooring forces but for storm conditions it is often the mooring loads that are of primary concern. The condition of the dock can have a significant influence as demonstrated by the following example of lateral wind area of a large floating dock as a percentage of the dock at operating freeboard, reference Figure 5:

- Dock at Deep Sink Freeboard: 25%
- Dock at Operating Freeboard: 100%
- Dock at Operating Freeboard with Large Vessel: 173%

In the majority of cases, docks are designed to accommodate storm conditions with a vessel on board. For severe storms such as hurricanes or typhoons this is often impractical and measures such as removing the docked vessel and/or lowering the dock in the water may be necessary. This requires the continuous monitoring of weather forecasts with an action programme to ensure that the dock can be prepared in good time. The operator therefore requires to establish the limiting wind speeds as part of the action plan. Limits are also required for such operations as docking and crane operations.

5.4 WAVES

Whilst the majority of docks operate in sheltered waters, large storms may give rise to considerable wave action. Where this is a problem the operator should define conditions and the appropriate course of action in the event of such extreme waves occurring. For example, in more exposed areas subject to typhoons or hurricanes, submerging the dock pontoon can considerably reduce the wave bending moments.

For docks operating on chain moorings away from quaysides/jetties where servicing is by workboat etc the sea conditions may give rise to difficulty of access and in such circumstances provisions on the dock should be arranged to ensure the dock crew and/or workers can be accommodated should such circumstances arise.

The other aspect that needs to be considered where large waves are concerned is wave slam under the aprons. Raising or lowering the dock depending on the prevailing circumstances can overcome this.

Ship generated waves are not normally a problem except in the case of small docks where heeling effects may cause temporary operational problems with craneage etc. In these circumstances it may be necessary to consider such measures as speed restrictions or limiting the distance a vessel can approach.

6. MAINTENANCE & INSPECTION

6.1 STRUCTURAL CONDITION

Classification societies only began to introduce rules in the 1970s and 80s for the construction of floating docks and consequently most old docks are unclassed. In addition, many newer docks, although built to class, are not maintained in class. This is because docks do not operate in the same regulatory environment as ships. The condition of docks is therefore often overlooked by the operator and since many of the vessels being docked will not be at the full capacity of the dock, decreasing strength will go undetected until too late.

With improved coatings, cathodic protection, underwater surveys and ultrasonic thickness measurements, the ability to dock floating docks is not so important. The problem areas are usually the sidewall tank spaces and the upper areas of the pontoon. – all accessible without the need for dry docking. As the condition deteriorates due to corrosion, the operator can either opt for renewal, down rating or a combination of both.

The operator should regularly monitor the structural condition of the dock for wastage and also check for local deformation due to overloading, particularly in way of the main transverses and centreline bulkhead. Other areas that are sometimes overlooked are the condition of keel and bilge blocks bases and their timber blocks.

6.2 INSPECTION

The dock should be subject to regular inspection by competent engineers. Due to lack of a regulatory environment docks often have little in the way of inspections except when classed or at the request of insurers. This is an area that requires much more attention since structural failure could jeopardise future business for the operator and at worse could result in loss of the dock and/or ship.

However, inspection should not be limited to the structural condition as other aspects affecting safety need to be considered such as condition of shore feeders, generators, pumping plant, control and monitoring systems etc. A checklist of the dock structure and equipment should be prepared to assist in this.

Dock operators should occasionally check that the correct relationship between dock blocks, dock deflection and deflection monitoring system is maintained. It is important to ensure that for the zero bending moment condition the dock blocks are level, accommodating any deflections in the dock whilst the deflection indicators read zero. Where docks have an inherent deflection the dock block heights will vary and will require to be used in specified positions.

6.3 MONITORING

Docks should be regularly monitored particularly with a vessel onboard. Whilst there may be a small valve leak in the light condition this may increase rapidly when supporting a vessel with an increased head of water in way of the valves. This could cause the dock to heel.

Other considerations are limitations, when at the operating freeboard, on manholes that can be open at any time, particularly on the pontoon deck. For example rainwater or wave action can cause water ingress through open manholes in the pontoon deck leading to progressive flooding of tanks. With small operational freeboards the pontoon deck can become quickly immersed in way of the manholes leading to rapid flooding of the open tank leading to a consequent stability reduction and possible overloading of the structure.

Heel and trim alarms are useful for identifying problems and can be arranged to monitor a dock at all times.

7. TRAINING

The operator requires to ensure that he understands the principles of a floating dock design. For example an operator may not appreciate that, unlike the case for ships, bulkheads are usually designed for only differential hydrostatic loading. Therefore leaving a compartment dry for maintenance could result in bulkhead or bottom plating overloading.

It is often the case that dock operators have only a partial understanding of the operation of a floating dock. Such knowledge is often informally passed down from one operator to the next. Dock operators should therefore receive training in the operation of the dock, some of which may be unique to their dock, and should typically include:

Principles of dock design
Assessing the suitability of ships for docking (strength, stability, ship support etc)
Preparation of pumping plans
Operating a floating dock
Handling of ships in and out of dock
Precautions
Emergency procedures

It is also possible to provide simulation of a floating dock operation in real time to enable new operators to learn how to operate a dock and also to identify and respond to various problems such as poor block fit, pump failure, ‘sticking ‘ valve, etc.

8. DOCUMENTATION

8.1 OPERATING MANUAL

Many docks lack the comprehensive documentation necessary to examine adequately all docking scenarios, how to safely operate the dock or how to manage the dock. This is often due to a lack of available design information particularly in older docks were information provided was very basic or has been lost over the years.

It is considered essential that in today’s environment dock operators should have an operating manual providing this information which should typically cover the following topics:

- General Particulars

  This should cover the dock’s overall dimensions, capacity, general arrangement and dockwell dimensions and clearances.

- Principal Systems

  Line diagrams covering the Dewatering System, Electrical System, Fire and Washdown System etc

- Design Drawings

  Drawings of the principal structural features, e.g. midship section, and key plan showing blocking areas etc. to facilitate the lay out of blocks to suit different vessels.

- Strength Limitations

  Information on the maximum longitudinal and transverse bending moments and shear forces, deflection limits, keel and bilge block load limits, maximum longitudinal distributed load, pontoon deck loadings.

- Stability

  Stability curves/tables giving maximum displacement/centre of gravity, hydrostatic tables, tank capacity tables, lightship weight and centre including inclining test or lightweight measurements.

- Freeboard

  Details of operating and deep sink freeboards and, where air cushions are used, the length of air pipes in the tank spaces. Freeboard adjustment, if any, for weather conditions, crane movements etc.

- Operating Procedure

  Step by step description from preparing the dock for docking, conducting a docking evolution, care during the lay period, preparing for undocking and carrying out an undocking. This should cover communication between ship, dock and tug personnel, handling of vessel into and out of the dock, operational sequence of raising/lowering the dock and how to control the dock e.g. manipulate valves to control draft, trim, heel and deflections

- Operating limitations

  Maximum allowable trim or heel. Also, maximum allowable water level differences between adjacent tanks and outside water level and the minimum pumpable ballast level (residual ballast level). Maximum lift capacity

- Emergency Procedures

  Procedures for dealing with flooding, fire, loss of communication, power loss or a system failure

- Pumping Plans

  Instructions on how to prepare pumping plans

- Precautions

  Precautions to observe when a vessel is on the dock e.g. manhole access, weight changes, monitoring of dock draft for leakage, tank levels, crane operation, etc.

- Storm Procedures

  Procedures for dealing with storms, i.e. wind and waves with and without docked vessels.

- Responsibilities

  Responsibilities and duties of personnel associated with the dock. E.g. Dockmaster, Deputy Dockmaster, Chief Engineer, Engineers, Electricians, Line Handlers, Riggers, Crane Operator etc.

- Environmental Limitations

  The maximum wind, tide or current under which a docking/undocking can be carried out. Maximum weather criteria and procedures to be followed in the event of excessive wind/wave forecasts.

The operating manual should contain sufficient information to enable a novice operator to operate the dock and for engineers to determine the suitability to undertake any type of docking.

8.2 DOCKING/PUMPING PLANS

Prior to any docking operation being carried out the operator requires to check that the dock can safely accommodate the vessel. This is particularly important the larger the vessel is relative to the lift capacity. Typically a docking plan should be prepared which covers the following:

- Dimensional Check (draft, beam, length etc)
- Position of vessel on dock and extent of blocking length, arrangement of blocks
- Stability of Dock with Ship throughout the docking evolution
- Determination of idealised weight distribution
- Ballast Distribution for key stages in the lift (e.g. operating freeboard, waterline to top of blocks, waterline at half ship's draft) and associated draft.
- Bending Moments and shear forces for longitudinal and transverse strength at the key stages of lift
- Block Loadings
- Programme of events giving approximate timings – for docking and undocking

9. SAFETY MANAGEMENT

Although there is currently no international standard specific to floating docks for their safe management, it is recommended that dock operators should provide a documented safety management system for their dock operations. The requirements of such a system could be adapted from that already required for ships under the International Maritime Organisation's resolution A.741(18) 'International Management Code for the Safety Operation of Ships and for Pollution Prevention'. Therefore as a guide, the document would cover such issues as:

(a) Safety and environmental protection policy

The operator should set out their safety and environmental policy to ensure safety of the dock, prevention of human injury or loss of life, and avoidance of damage to the environment and property.

(b) Responsibilities and authority

The operator should define the responsibility, authority and interrelation of all personnel who manage, perform and verify work relating to and affecting safety and pollution prevention.

The operator is responsible for ensuring that adequate resources and support are provided to enable the designated person or persons to carry out their functions.

(c) Designated person(s)

The operator should designate a person or personnel responsible for ensuring that the dockmaster's organisation of crew can efficiently deal with docking evolutions and any emergencies that may arise. They should also be responsible for checking the suitability of the dock for docking a ship, the preparation of docking/pumping plans and assessment of emergency situations. They should have direct access to the highest levels of management and should be available at all times during a docking evolution.

(d) Dockmaster's responsibility and authority

The operator should define the dockmaster's responsibility in implementing the safety management system and emphasise the dockmaster's overriding authority to make decisions in regard to safety and pollution prevention and to request the operator's assistance as necessary.

(e) Resources and personnel

The operator should ensure that the dock is operated and manned by suitably qualified and experienced personnel. They should provide procedures to ensure that new personnel receive proper familiarisation of the dock and training as appropriate.

(f) Development of plans for floating dock operations

The operator should establish procedures and instructions for undertaking docking evolutions. It should cover such items as:

- Assessment of the suitability of a ship for docking.
- Preparation of docking plans.
- Procedure for bringing a vessel into the dock, utilisation of berthing systems, and positioning
- Responsibilities and duties of personnel during the various stages of a docking evolution. This should include designated persons, dockmaster, dock crew, ship's master, ship's superintendent, tug master, etc.
- Operation of the floating dock (see also section 8.1 'Operating Manual')

(g) Emergency preparedness

Procedures should be established to enable the operator to respond to emergency situations. This includes failure of dock systems, loss of shore supplies, ship or dock fires, storms, damage to dock and/or ship, pollution, etc.

Drills and exercises should be provided to prepare for emergency situations.

(h) Reports and analysis of non-conformities, accidents and hazardous occurrences

A system of reporting non-conformities, accidents and hazardous situations should be provided to enable investigation to improve safety and pollution prevention and the implementation of corrective actions.

(i) Maintenance of the floating dock and equipment

A system of maintenance should be established to ensure that the dock and its equipment are maintained to a satisfactory and relevant standard. Critical systems such as the pumping system, dock control systems and power supplies should be identified and be subject to regular inspection and testing. Provision should be made for regular inspection, identifying non-conformances, corrective action and recording.

(j) Documentation

Documentation relating to the safety management system, dock operating manual etc should be controlled documents in accordance with normal quality assurance procedures and available to the relevant personnel in the appropriate locations e.g. dockmaster's office.

(k) Company verification, review and evaluation

The operator should provide a system of verification, review and evaluation by undertaking audits and reviews in accordance with normal quality assurance practice and ensure that deficiencies found are corrected in a timely manner.

(l) Certification, verification and control

Whilst there is no international code specific to dock operations to enable a certificate of compliance to be provided, operators will need to ensure that the issues raised in this paper are adequately addressed under their existing quality assurance certification e.g. ISO 9000.

10. MODERN TECHNOLOGY

With increasing levels of computerisation in the industry it is relatively straightforward to provide better levels of information, for example:

- Preparation of docking/pumping plans with a simple amount of input.

- For docking operations, the various inputs from tank levels, dock drafts, heel, trim and deflection systems can be continuously monitored throughout a docking evolution. They can be combined to give the differential hydrostatic loading on bulkheads and assess transverse loadings. The various input values and analysed values can be automatically compared against allowable criteria giving audible warnings as appropriate.

- For watchman type duties, to monitor trim, heel and draft for changes during the lay period

11. CONCLUSION

All dock operators should ensure that they have suitably prepared procedures and training and that their docks are properly equipped with the necessary control and monitoring systems. They should have detailed operating manuals to provide the necessary information to examine all types of docking scenarios and establish responses to system failures or hazards. They should prepare pumping plans for comparison with actual conditions to check the suitability for docking and enable identification of problems during docking.

Dock designers should ensure that the dock is provided with sufficient systems to enable its safe operation and that the operator is provided with sufficient information to enable any normal or unusual docking to be adequately assessed.

It is recommended that there should be an internationally recognised standard for the operation of floating docks to ensure that all docks are properly maintained and operated. Such a standard could be applied as part of an operator's quality assurance programme.

With the type of arrangements discussed, operators should continue to lift all types of vessel safely and with confidence.

David Westmore holds the current position of Managing Director at Clark & Standfield. His previous experience includes numerous floating dock projects, both naval and commercial, involving design, operation, surveys, towage, etc.