Dorman Long Technology

DL-TS3000 Modular Jacking Tower System

Modular jacking tower system for erection of petrochemical vessels weighing up to 3,000 metric tonnes

CONTENTS

1.0 INTRODUCTION

The DL-TS3000 Modular Jacking Tower System combines proven lifting technologies to produce a compact and cost effective system that will erect a wide range of super-heavy vessels in the oil and gas construction market. The system can also be adapted for use in a variety of applications outside the petrochemical industry. To date the DL-TS3000 tower system has been used to erect offshore structures weighing up to 2800 tonnes, goliath crane girders weighing up to 6,000 tonnes, large roof structures weighing up to 2,600 tonnes and petrochemical vessels weighing up to 1,350 tonnes.

The DL-TS3000 tower system is available in two interchangeable tower strengths, Mk1 and Mk2. The Mk2 towers are stronger and are able to free stand to greater height.

Dorman Long Technology have been at the forefront of jacking tower design for the past 20 years and have been responsible for designing many of the systems in use today. The DL-TS3000 is the result of listening to the requirements of EPC contractors and heavy lift contractors over many years and has the following main benefits:-

- **High lifting capacity** — In twin tower configuration the DL-TS3000 will erect vessels weighing up to 3,000 tonnes.
- **Freestanding or guyed configurations** — Depending on the loads to be lifted and the tower height required, the DL-TS3000 can be used in either freestanding or guyed configurations.
- **Compact** — Two towers placed close to the vessel uses up very little space on site and allows the tower system to be supported on the vessel foundation.
- **Transportable in containers** — All elements of the DL-TS3000 have been designed to fit into standard shipping containers for economic transport between sites
- **Foundation options** — The DL-TS3000 can be supported on extensions to the vessel foundations, temporary concrete foundations, load spreading mats or a base skidding system can be used.
- **Modular** — The DL-TS3000 is a modular system designed to offer maximum configuration flexibility.
- **Vessel alignment** — The DL-TS3000 has the ability to rotate and laterally skid the lifted vessel.
- **Computer control system** — The DL-TS3000 utilises a computer control system with data logging to control and monitor all jacks and hydraulic power packs.
- **High wind capability** — The DL-TS3000 is able to operate in wind speeds of 20 m/s or more and is stable in storm wind speeds of 40 m/s or more.

The following pages describe the tower system, foundation arrangements, jacking equipment and jacking control system.

Please contact us for more detailed information on lifting capacities and foundation loads for specific project parameters. Contact details are given at the end of this brochure.

2.0 GENERAL DESCRIPTION

The DL-TS3000 jacking tower system can be used in two-tower or four-tower configuration, freestanding or guyed and using either strand jacks or climbing jacks for lifting. Vessels can be lifted, skidded laterally and rotated as required to suit the delivery position.

Lifting is carried out using either strand jacks mounted on a crosshead beam at the top of the tower or using 450 tonne capacity climbing jacks that rise with the load on square steel climbing bars which are clipped to the inside face of the towers. Up to 4 No climbing jacks can be used per tower, 8 No total for a twin tower system. The jacking systems are monitored and controlled from ground level by a single operator using the Dorman Long Technology DL-P40 computer control system.

Once the vessel has been lifted to the required elevation, a number of positional adjustments can be made as follows:-

- The vessel's transverse position can be adjusted using a gripper jack system mounted between the swivel beam and the crosshead beams.
- The vessel's plan orientation can be adjusted by means of the swivel.
- The vessel's vertical position can be adjusted by operating the strand jacks.

The tower sections are supplied in 11.4m and 5.7m lengths, each with four legs at 3.5m centres. The tower sections are pre-assembled at ground level with simple pinned bracing and incorporating ladders and platforms. Each section is lifted and placed on top of the previous section, automatically aligned with stabbing guides and the legs bolted. The bolts can be easily accessed from the tower platforms. A fully assembled 11.4m tower section, complete with internal ladders and platforms weighs 21 tonnes for the Mk1 tower system and 32.5 tonnes for the Mk 2 tower system. Climbing bars, if fitted, add a further 4 tonnes per bar.

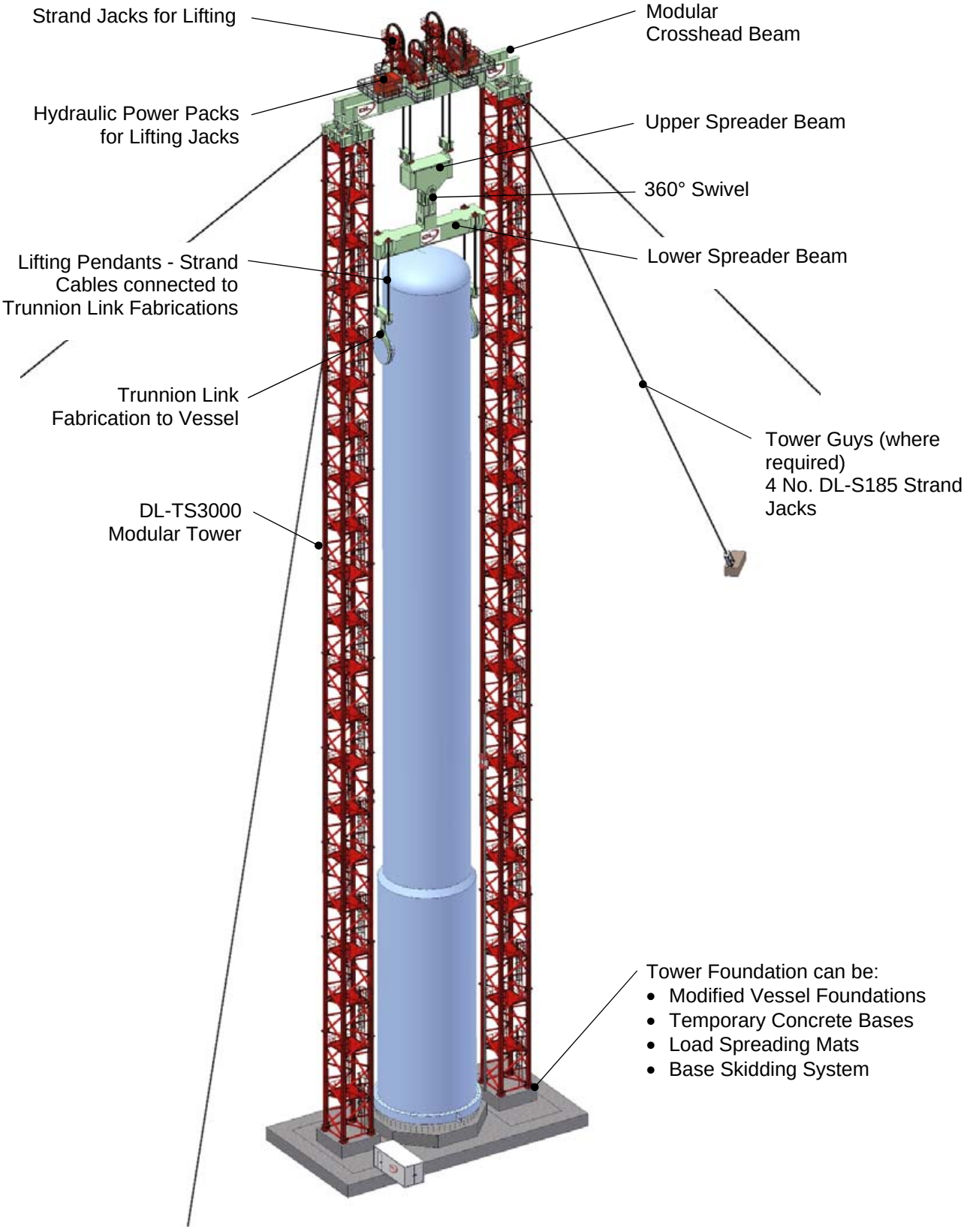
There are two versions of the DL-TS3000 tower designated the MK 1 and MK 2. The two types are visually similar and are fully compatible and interchangeable with each other, but the MK 2 legs are stiffer providing a higher capacity. One option is to use MK 2 legs in the lower section of a free standing tower where the loads are greater and lighter MK 1 legs in the upper section.

For the strand jack configuration a modular crosshead beam is placed across the tops of the towers for mounting the jacks and power packs. This allows tower centres to be varied whilst maintaining a high lifting capacity. For the climbing jacks the climbing bars are clipped to the outside face of the tower sections at the assembly stage.

If a swivel is required this consists of an upper spreader beam, a swivel and a lower spreader beam. The lower spreader beam is connected to the vessel using pendants and trunnion link fabrications. When a vessel incorporates a top lug the swivel can be connected directly to this lug via link plates.

All components are designed and manufactured for transport in standard shipping containers.

In the most common configuration, the system uses two towers with strand jacks mounted on a crosshead beam as illustrated on the opposite page.


Strand Jacks for Lifting
Modular Crosshead Beam
Hydraulic Power Packs for Lifting Jacks
Upper Spreader Beam
360° Swivel
Lifting Pendants - Strand Cables connected to Trunnion Link Fabrications
Lower Spreader Beam
Trunnion Link Fabrication to Vessel
Tower Guys (where required)
4 No. DL-S185 Strand Jacks
DL-TS3000 Modular Tower
Tower Foundation can be:
• Modified Vessel Foundations
• Temporary Concrete Bases
• Load Spreading Mats
• Base Skidding System

Other Applications

The tower system can be adapted for a variety of applications outside the petrochemical industry and this versatility is illustrated by the examples below.

Roof Erection:
The example shown here used the DL-TS3000 towers with Strand Jacks. An aircraft hangar roof weighing 3,500 tonnes was pre-assembled at ground level and lifted 30 metres to its final position.

Gantry Crane Erection:
The DL-TS3000 system incorporating Climbing Jacks was used to lift one end of a gantry crane.

Jacket Construction:
This Wellhead Platform, 140 metres tall and weighing 2,800 tonnes, was built using the DL-TS3000 system in four-tower configuration with Climbing Jacks. The jacket was incrementally lifted to allow sections to be inserted beneath.

3.0 SYSTEM SPECIFICATION

The following data is intended for initial evaluation purposes only. Please contact us with your specific project requirements.

The system specification is as follows.

Lifting Capacity:	See tables below
Lifting Speed:	10 to 30 m/hr
Maximum Tower Spacing:	60 m
Maximum Lifting Wind Speed:	20 m/s
Maximum Storm Wind Speed:	40 m/s
Operating Temperature Range:	-20 to +50°C
Guys (where required):	4 No. DL-S185 strand jacks (185 tonnes SWL each)

Notes for tables below:
Lifting capacities are gross and include the weight of the vessel plus all lifting accessories including strand, lifting beams and swivel.
Capacities based on two-tower configuration, 20 metre tower spacing with vessel central to towers.

DL-TS3000 MK 1 Gross Lifting Capacities

No of 11.4m Tower Sections	Tower Height (m)	Strand Jacks		Climbing Jacks	
		SWL Guyed (tonnes)	SWL Freestanding (tonnes)	SWL Guyed (tonnes)	SWL Freestanding (tonnes)
2	25.6	3000	2800	3600	3600
3	37.0	2950	2275	3600	3300
4	48.4	2900	1750	3600	2400
5	59.8	2875	1300	3600	1750
6	71.2	2850	950	3600	1325
7	82.6	2800	675*	3600	1025
8	94.0	2775	450*	3600	825
9	105.4	2750	275*	3600	650*
10	116.8	2550		3600	500*
11	128.2	2300		3600	375*
12	139.6	2075		3600	
13	151.0	1800		3600	
14	162.4	1550		3250	
15	173.8	1300		2900	

* Indicates out of service wind speed less than 40 m/s.

DL-TS3000 MK 2 Gross Lifting Capacities

No of 11.4m Tower Sections	Tower Height (m)	Strand Jacks		Climbing Jacks	
		SWL Guyed (tonnes)	SWL Freestanding (tonnes)	SWL Guyed (tonnes)	SWL Freestanding (tonnes)
2	25.6	3000	3000	3600	3600
3	37.0	3000	3000	3600	3600
4	48.4	3000	2975	3600	3500
5	59.8	3000	2850	3600	3400
6	71.2	3000	2275	3600	2850
7	82.6	3000	1700	3600	2300
8	94.0	3000	1325	3600	1925
9	105.4	3000	950	3600	1550
10	116.8	3000	700*	3600	1275
11	128.2	3000	450*	3600	950*
12	139.6	3000	275*	3600	675*
13	151.0	3000	100*	3600	400*
14	162.4	3000		3600	
15	173.8	2900		3600	

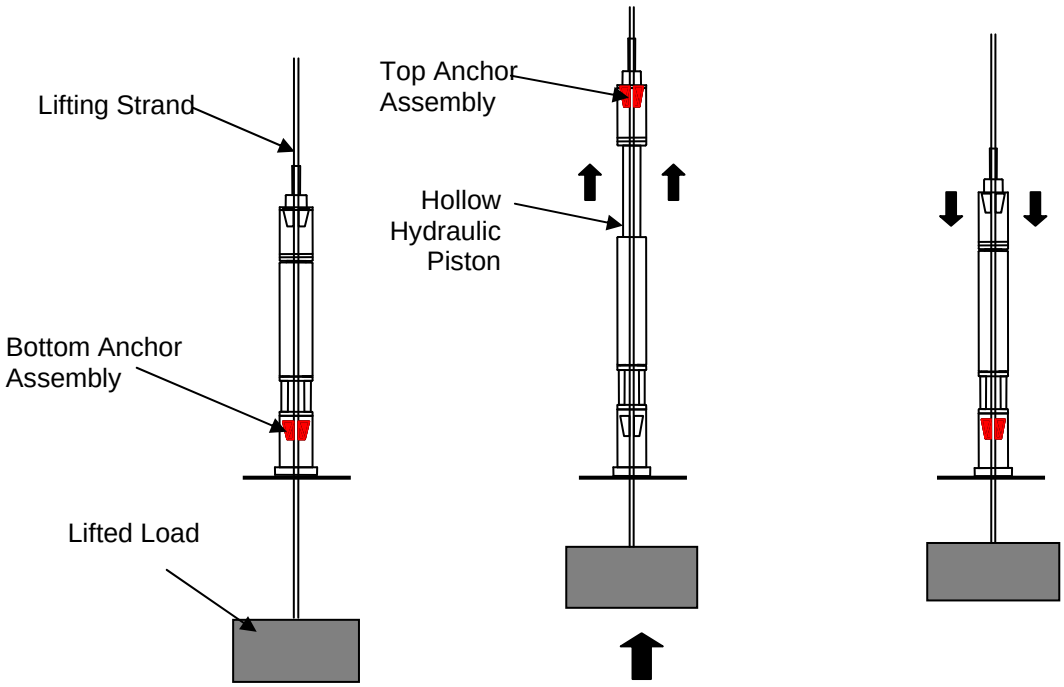
* Indicates out of service wind speed less than 40 m/s.

4.0 DESCRIPTION OF JACKING EQUIPMENT

The DL-TS3000 utilises either strand jacks or climbing jacks for lifting depending upon project requirements. The following sections give a brief introduction to each type of jack.

4.1 Strand Jacks

Strand jacks were initially developed from the wedge gripping technology used in post-tensioned concrete and have been developed for specific use as lifting, lowering and pulling jacks. Each jack consists of a bottom anchor assembly, the main hollow hydraulic piston, and a top anchor assembly. Each anchor assembly consists of a series of tapered wedges, which will automatically form a mechanical lock against the lifting strand. The operation of the hollow hydraulic piston moves the lifting strand through the jack, automatically transferring support between the top and bottom anchor assemblies. This is shown in simplified form below.



Stage 1
Load held in bottom anchor assembly

Stage 2
Extend jack. Load transferred to top anchor assembly. Strand pulled through bottom anchor as load is lifted.

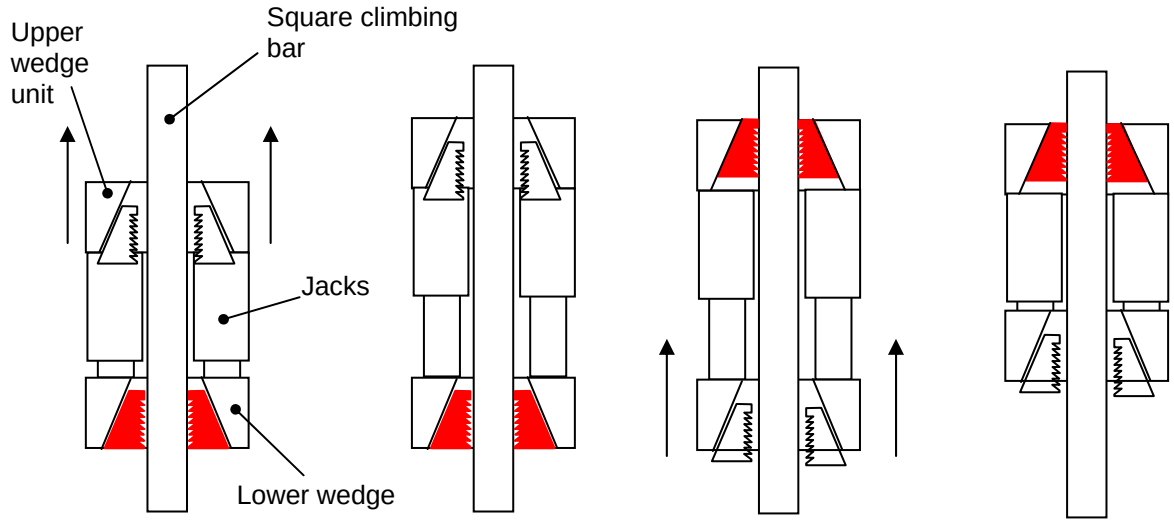
Stage 3
Retract jack. Load transferred to base anchor. Strand pushed through top anchor as load is held at the bottom anchor.

Strand jacks are available in a wide variety of capacities varying from 15 tonnes to 1022 tonnes. Each lifting strand consists of 7 individual wires formed into a single strand approximately 18mm diameter. The minimum-breaking load of each strand is 38 tonnes. Each strand has a working capacity of 15 tonnes, thereby providing a 2.5 factor of safety. Jacks of capacities greater than 15 tonnes, use a series of these strands arranged in a group to achieve the required capacity.

4.2 Climbing Jacks

In the two-tower configuration, the system can utilise up to eight DL-C450 climbing jacks. Each of the DL-C450 climbing jacks has a safe working load of 450 tonnes and uses a proven system of gripping wedges to climb up and down a 200mm x 200mm square steel bar which is attached to an outside face of the tower. Climbing jacks have been used as an effective and reliable method for erecting vessels for over 30 years.

Each climbing jack comprises an upper wedge unit, a lower wedge unit and a pair of solid hydraulic rams which sit between the wedge units. The wedge units grip the square steel bar and work in sequence with the jacks to move along the bar as shown in simplified form below.



Stage 1
Load held in lower wedge unit
Jacks extend to raise upper wedge unit

Stage 2
Load held in lower wedge unit
Jacks fully extended

Stage 3
Load transferred to upper wedge unit
Jacks retract to raise lower wedge unit

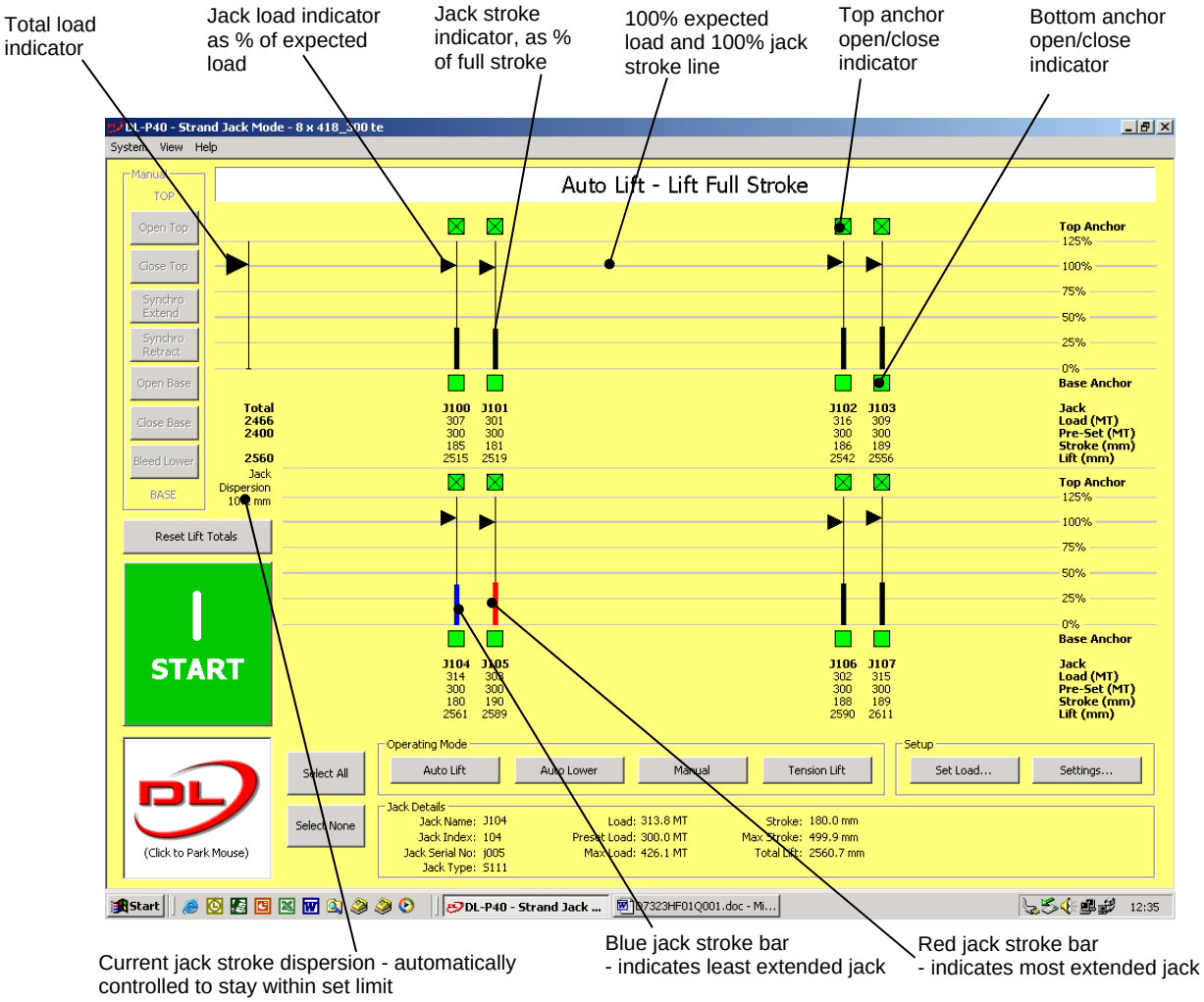
Stage 4
Load in upper wedge unit
Jacks fully retracted
Load transferred back to lower wedge unit

5.0 DESCRIPTION OF CONTROL SYSTEM

All jacking systems on the DL-TS3000 are monitored and controlled by the DL-P40 computer control system, developed by DLT. This system uses the latest CAN-bus network for reliable and robust communication over long distances and the hardware and software are both fully tested and certified to European standards for Electro-magnetic interference which is an important issue when used on a construction site.

The DL-P40 computer control system provides the operator with a clear presentation of all essential data on jack loads and extensions and automatically synchronises the operation of the jacks to maintain a level lift and an even load balance between the jacks. Up to 40 jacks can be controlled and synchronised simultaneously with this system, although on the DL-TS3000 in two-tower configuration, a maximum of 8 jacks will be controlled at any one time. The DL-P40 also saves a full data log of each lifting operation for post-lift analysis.

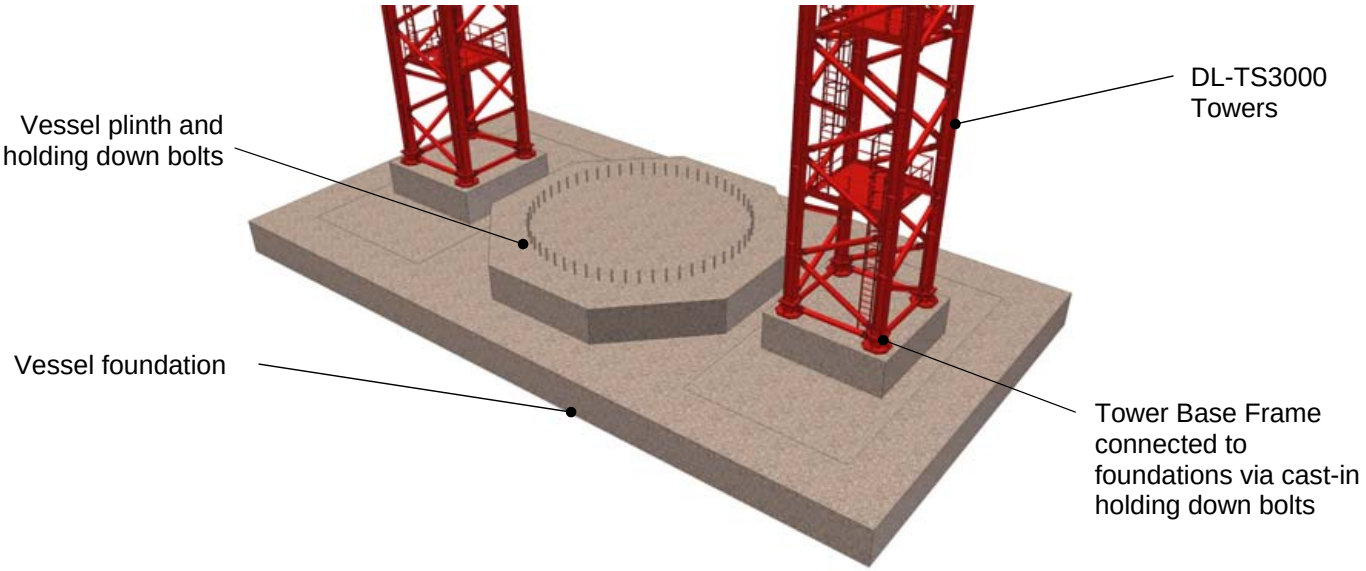
The DL-P40 computer control system has many inbuilt safety features to prevent unsafe operation of the jacking system. The system offers 3 main operating modes – Auto-Lift, Auto-Lower and Manual. Each mode operates all the selected jacks together. Auto-Lift and Auto-Lower modes automatically control all jack operations to lift and lower the load, maintaining jack extensions to within limits set by the operator. Manual mode provides full manual control of all jack operations and includes a bleed lower facility, which allows very slow lowering of the load for final level adjustment, to within +/- 1.0mm, or for lowering the load onto its permanent supports.



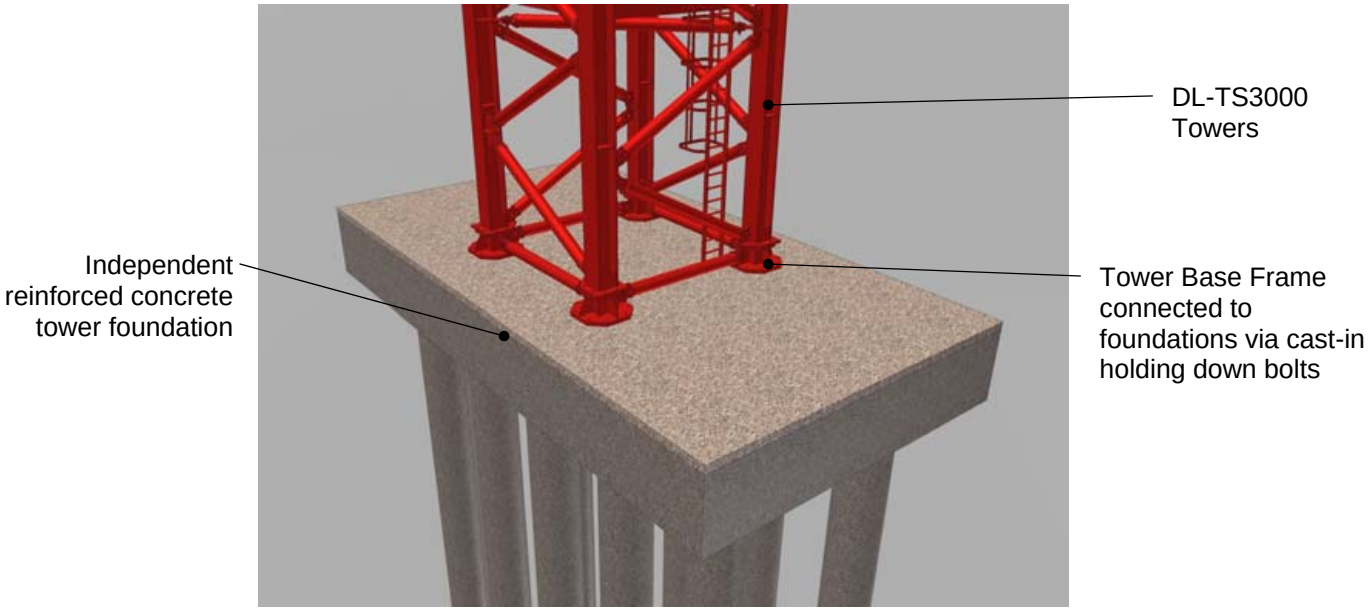
6.0 TOWER SYSTEM FOUNDATIONS

There are several options for providing a strong and stable foundation to the towers. The choice of tower foundation will depend on the constraints of each site. The options are as follows:-

6.1 Modify (extend) the permanent vessel foundations. By extending the permanent vessel foundation slab, the DL-TS3000 lifting towers can transfer the erection forces directly to the permanent foundation piles or rock head. This option provides the most economical means of supporting the tower system, particularly in soft ground conditions, but will require an early decision to use the DL-TS3000 so the vessel foundation can be designed accordingly.

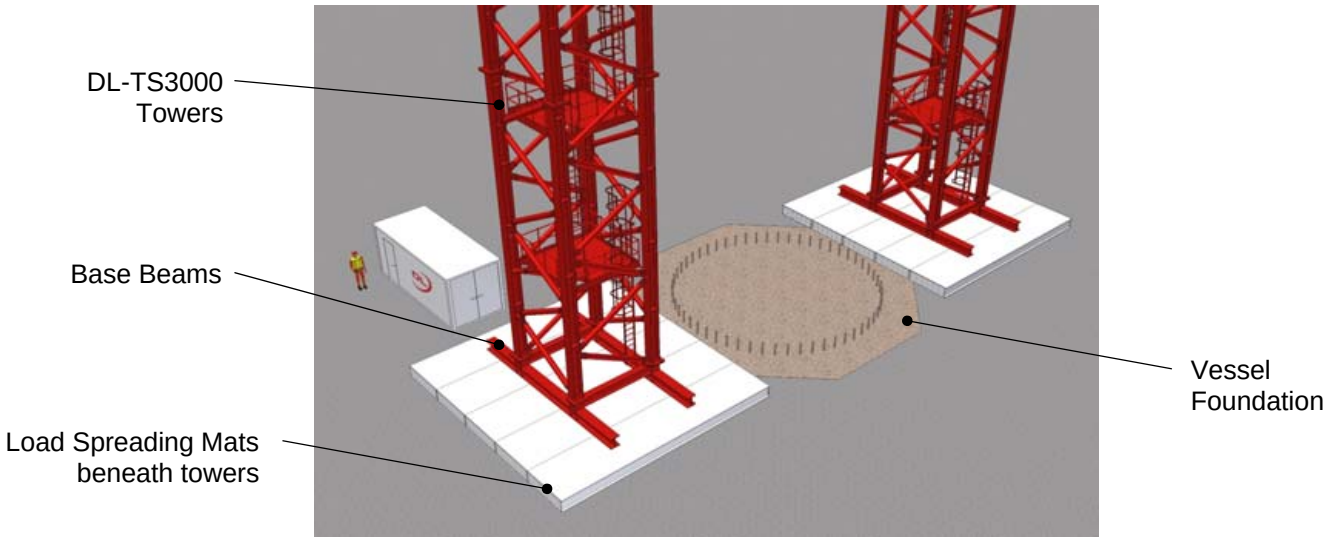


6.2 Provide temporary reinforced concrete foundations. By providing suitable temporary reinforced concrete bases under the DL-TS3000 lifting towers, the erection loads can be effective transferred into the ground. However, dependant on ground conditions, it may be necessary to provide piles to the temporary concrete bases and therefore this foundation solution if often more expensive. However, it may be the most appropriate option on projects where the vessel foundation has already been constructed, or where the lifting arrangement is such that the lifting towers are not close to the vessel foundations.

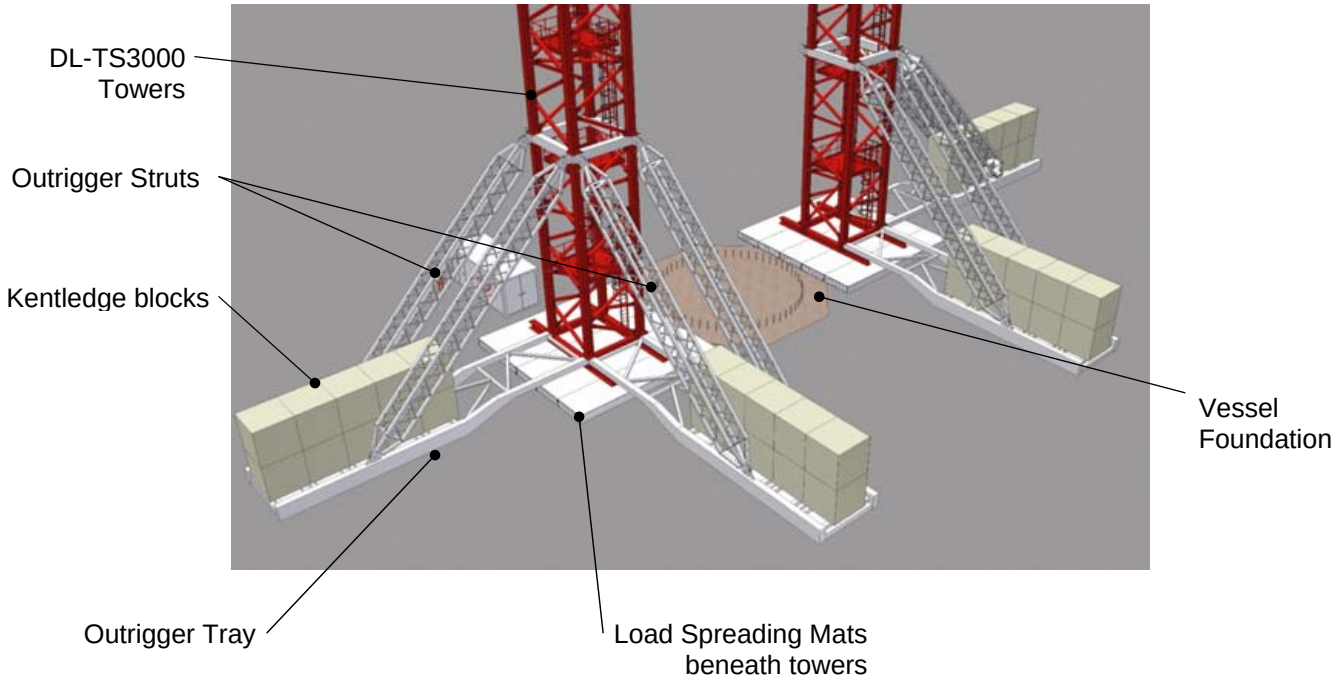


6.3 Provide load spreading mats. By providing modular load spreading mats under the tower, the vertical load from each tower is suitably spread to be within the maximum permissible ground bearing pressure of the site.

For towers in the guyed configuration, the towers are supported on base beams to spread the loads over the area of the mats. This option has the advantage that it does not require any significant civil engineering works. However, it does need reasonable ground conditions under the load spreading mats.

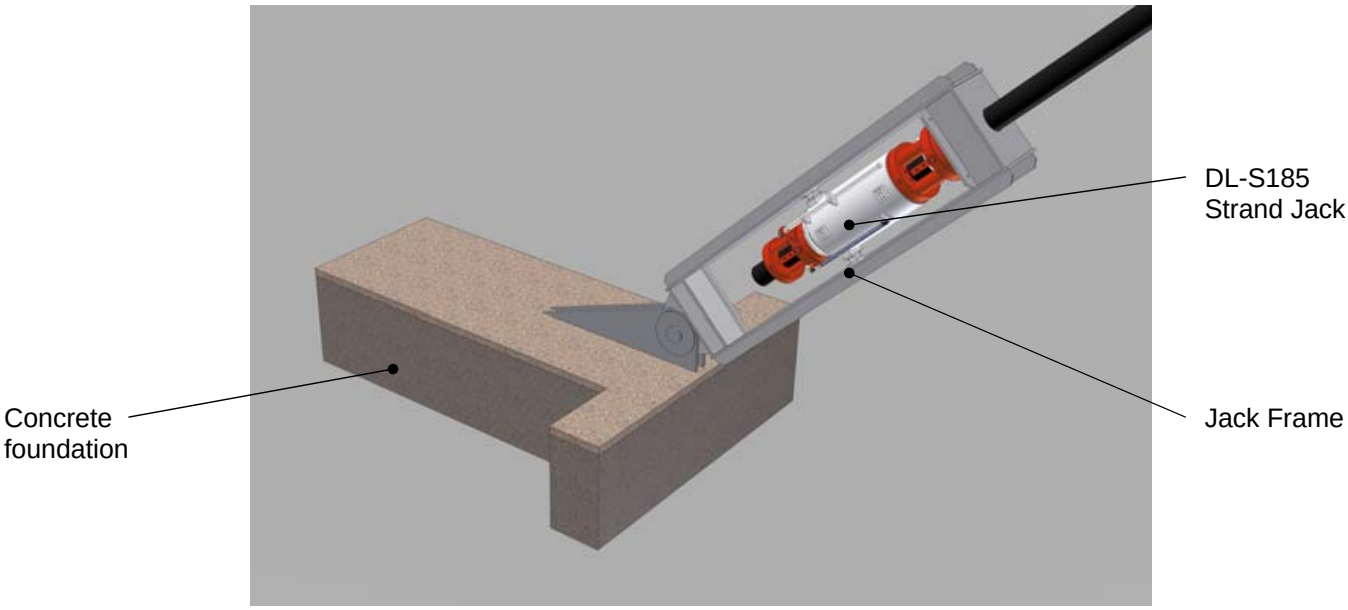


For towers in the freestanding configuration, due to the magnitude of the overturning moments, it is likely that base outriggers with ballasted outrigger trays would be required. This option has the advantage that it does not require any significant civil engineering works. However, it does need sufficient space around the towers for the outrigger trays and reasonable ground conditions under the load spreading mats and outrigger trays.

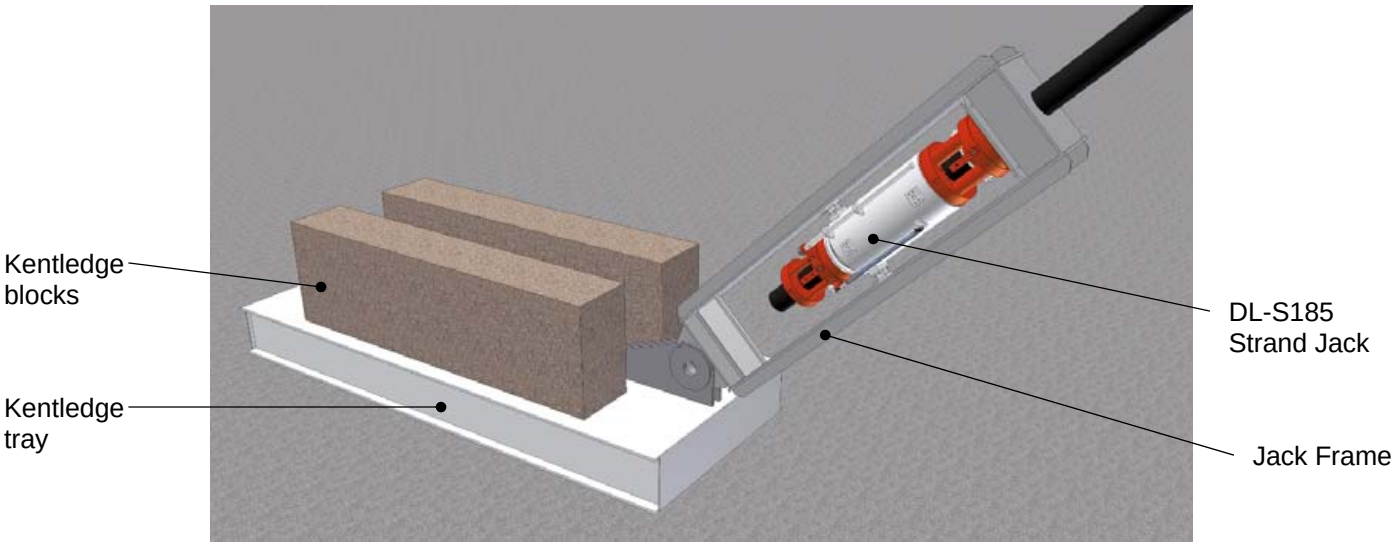


6.4 Guy foundations. Tower system guys (where required) utilise 4 No. DL-S185 strand jacks mounted in jack frames. The guys are attached to the top of each tower and the bottom end needs to be attached to a suitable foundation.

Option 1. Attach the bottom end of the guys to a concrete foundation. The horizontal forces are resisted by soil pressure on the front of the foundation and the vertical uplift forces by the mass of the concrete foundation (plus kentledge if required).



Option 2. Attach the bottom end of the guys to a steel kentledge tray. The horizontal forces are resisted by friction between the kentledge tray and the ground and the vertical uplift forces by the mass of the kentledge.



7.0 SYSTEM CERTIFICATION AND DOCUMENTATION

7.1 Design and Manufacture

The DL-TS3000 modular tower system is designed and manufactuerd to the highest standards.

The tower system has been designed under the following controls:-

- Designed by Dorman Long Technology's engineering division, who have been at the forefront of jacking tower design for the past 20 years and have been responsible for designing many of the tower systems in use today.
- Design process followed our independently certified ISO 9001:2008 quality management system.
- Design certificate and check certificate issued by Dorman Long Technology in accordance with our ISO 9001:2008 procedures.

The tower system is manufactured under the following controls:-

- Manufacturing process followed our independently certified ISO 9001:2008 quality management system.
- Steelwork fabricated with full traceablilty.
- Coded welding.
- Ultrasconic examination or magnetic partical inspection of welds as specified.
- Steelwork fabrication inspected and certified by Dorman Long Technology as being manufactured in accordance with our design & specification.

The primary jacking equipment used on the tower system is manufactured to our own design and:-

- All jacking equipment is tested to 125% overload and independently certified by Lloyds Register.
- All jacking equipment is fully examined before shipping.

7.2 Tower System Operation

Dorman Long Technology operates in accordance with an independently certified OHSAS14001 / ISO18001 environmental, health and safety management system. For each project and prior to arrival on site we will provide the following:-

- a comprehensive set of calculations for review by Client's engineers.
- a Health & Safety file including:-
    - risk assessments
    - method statements
    - equipment test certification
    - schedule of site safety briefings
    - sequence and assembly drawings
    - check lists & certification procedures
    - COSHH assessments
    - CV's of site staff

Once the tower system is erected on site it is surveyed and certified by DLT's Lift Master or DLT's Lifting Engineer prior to carrying out each lift. A Lift Report and a Log File from the DL-P40 control system will submitted following each lift.

8.0 CONTACT DETAILS

UK Head Office:
The Charles Parker Building, Midland Road,
Higham Ferrers, Northamptonshire, NN10 8DN, United Kingdom
Tel. +44 (0)1933 319133, Fax. +44 (0)1933 319135
Contact: David Dyer. david.dyer@dormanlong.com

UK Northern Office:
Whessoe Technology Centre
Morton Palms, Darlington
Co Durham, DL1 4WB, United Kingdom
Tel. +44 (0)1325 390010, Fax. +44 (0)1325 390054
Contact: Chris Wilkinson. chris.wilkinson@dormanlong.com

China Office:
Dorman Long Engineering Technology Consultant (Shanghai) Co. Ltd
19D, Ju Jia Building, 1336 Huashan Road
Changning District, Shanghai 200052
Tel. +86 (0) 21 62110500, Fax: +86 (0) 21 62110523
Contact: Hongyi Tao. hongyi.tao@dormanlong.com

India Representative Office:
217, Hallmark, Vasant Oscar, L.B.Shastri Marg,
Mulund (w) , Mumbai 400080, India.
Tel. +91 22 25921960
Contact: Rajeev Tipnis. rajeev.tipnis@dormanlong.com

Japan Representative Office:
Kobe Fashion Mart 4C-06
6-9, Koyocho-naka, Higashinada, Kobe
Hyogo 658-0032, Japan. Tel/Fax. +81 789 04 85 05
Contact: .Mr Toshiyuki Shimizu. t.shimizu@dormanlong.com