

CLAIMS

1. A pile handling facility (100) for tilting a pile (10) from a laying orientation (*L*) at least partly within a deck (205) of a vessel (200) to an upright orientation (*U*) outside an outer boundary of the deck (205), wherein the laying and upright orientations are defined as the orientation parallel and perpendicular to the deck (205) respectively,
- 5 the pile handling facility (100) comprising
- the vessel (200) comprising the deck (205) for storing at least one pile (10),
 - 10 • a lifting crane (400) fixed to the vessel (200) and dimensioned to lift the pile (10), the lifting crane (400) comprising
 - a crane cable (403) having, during tilting, a suspended end fixed to or near an upper pile end (10a) of the pile (10), and
 - an up-ending tool (3) for supporting the pile (10) during tilting from the laying orientation to the upright orientation, the up-ending tool (1) being
 - 15 rotatably fixed to the outer boundary of the deck (205) via at least one pivot hinge (3d) around a rotational axis parallel to the deck (205) and perpendicular to a longitudinal center axis (*C*) of the pile (10), the up-ending tool (3) comprising
 - 20 ○ a contacting face (3e) configured to abut against a circumferential surface of the pile (10) during tilting,
- characterized in that**
- the pile handling facility (100) further comprises
- a winch system comprising
 - 25 ○ a winch cable (8) fixed, during tilting, at an end to or near the upper pile end (10a) and
 - a winch tension controller configured to control a winch tension (T_w) in the winch cable (8), comprising a drum (5) onto which the winch cable (8) is spooled.
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2. The pile handling facility (100) in accordance with claim 1, wherein the winch tension controller (5,7) further comprises
- a winch tension sensor (7) configured to measure the winch tension (T_w).
3. The pile handling facility (100) in accordance with claim 1 or 2, wherein the pile handling facility (100) further comprises
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- a suspending structure (4) removably fixed to the upper pile end (10a) during tilting,

wherein both the suspended end of the crane cable (403) and the end of the winch cable (8) are fixed to the suspending structure (4).

- 5 4. The pile handling facility (100) in accordance with claim 3, when dependent on 2, wherein the winch tension sensor (7) is a load cell interconnecting the end of the winch cable (8) with the suspending structure (4).
- 10 5. The pile handling facility (100) in accordance with any one of the preceding claims, wherein the winch tension controller (5,6) further comprising
 - a drum motor (6) configured to rotate the drum (5) around a rotational axis perpendicular to the orientation of the winch cable (8), and wherein the winch tension controller (5,6) is configured to control operation of the drum motor (6).
- 15 6. The pile handling facility (100) in accordance with claim 5, wherein the drum motor (6) is configured to control the rotational velocity of the drum (5) during rotation and wherein the winch tension controller (5,6) further comprising means
 - for calculating a desired rotational velocity as function of the measured winch tension (T_w) and
 - 20 for regulating the drum motor (6) to achieve the desired rotational velocity.
- 25 7. The pile handling facility (100) in accordance with any one of the preceding claims, wherein the lifting crane (400) further comprises
 - a crane tension sensor (407) configured to measure a crane tension (T_C) in the crane cable (403).
- 30 8. The pile handling facility (100) in accordance with claim 7, when dependent on claim 6, wherein the winch tension controller (5-7) comprises means to receive the measured crane tension (T_C) and to calculate the desired rotational velocity as function of both the measured winch tension (T_w) and the measured crane tension (T_C).
- 35 9. The pile handling facility (100) in accordance with any one of the preceding claims, wherein the upending tool (3) further comprises
 - a pivot base (3c) fixed to the at least one pivot hinge (3d) and
 - an end support (3a) protruding from or near a lower end of the pivot base (3c),

wherein the pivot base (3c), the at least one pivot hinge (3d) and the end support (3a) are configured such that a lower pile end (10b) of the pile (10) may be supported on the end support (3a) during tilting.

- 5 10. The pile handling facility (100) in accordance with any one of the preceding claims, wherein the upending tool (3) further comprises
- a pivot base (3c) fixed to the at least one pivot hinge (3d) and
 - an upper support (3b) protruding from or near an upper end of the pivot base (3c), wherein the upper support (3b) comprises the contacting face
- 10 (3e).
11. The pile handling facility (100) in accordance with claim 10, when dependent on claim 9, wherein the ratio of
- 15 an end support distance (D_{es}) between the end support (3a) and the pivot hinge (3d) and
- an upper support distance (D_{us}) between the upper support (3b) and the pivot hinge (3d)
- is at least 1.
- 20 12. The pile handling facility (100) in accordance with claim 10 or claim 11, wherein the upper support (3b) is pivotably fixed to the pivot base (3c) such that the upper support (3b) may pivot between
- a contacting position where continuous contact is present between the contacting face (3e) and the circumferential surface of the pile (10) and
- 25 a release position displaying a horizontal spacing between the contacting face (3e) and the circumferential surface of the pile (10).
13. The pile handling facility (100) in accordance with any one of the preceding claims, wherein the contacting face (3e) has a concave form seen along the
- 30 longitudinal center axis (C) of the pile (10) with a radius equal, or near equal, to the radius of the pile (10).
14. A method for tilting a pile (10) from a laying orientation at least partly within a deck (205) of a vessel (200) to an upright orientation outside an
- 35 outer boundary of the deck (205) by use of a pile handling facility (100) in accordance with any one of the preceding claims,
- wherein the method comprises the following steps:

- 5 A. arranging the pile (10) into the upending tool (3) such that the contacting face (3e) abuts against the circumferential surface area of the pile (10),
- B. lifting the upper pile end (10a) by use of the lifting crane (400) such that the pile (10) and the upending tool (3) is tilted around the rotational axis while the contacting face (3e) remains in abutment with the circumferential surface area and,
- 10 C. during at least a part of the tilting, regulating operation of the drum (5) by use of the winch tension controller in order to maintain the winch tension (T_w) above a minimum winch tension value (T_{wmin}^*).
- 15 15. The method in accordance with claim 14, wherein the winch tension controller (5-7) further comprising
- a drum motor (6) configured to rotate the drum (5) around a rotational axis perpendicular to the orientation of the winch cable (8) and
 - a winch tension sensor (7) configured to measure the winch tension (T_w), wherein the method further comprises the steps:
 - measuring the winch tension (T_w) by use of the winch tension sensor (7),
 - calculating operational instructions for the drum motor (6) as function of the measured winch tension (T_w) to achieve a desired winch tension (T_{wd}) in the winch cable (8) and
 - setting the drum motor (6) in accordance with the calculated operational instructions.
- 20 16. The method in accordance with claim 15, wherein the lifting crane (400) further comprises
- a crane tension sensor (407) configured to measure a crane tension (T_C) in the crane cable (403), wherein the method further comprises the steps:
 - measuring the crane tension (T_C) by use of the crane tension sensor (407) and
 - calculating operational instructions for the drum motor (6) as function of the measured winch tension (T_w) and the measured crane tension (T_C) to achieve the desired winch tension (T_{wd}) in the winch cable (8).
- 30 17. The method in accordance with any one of claims 14 to 16, wherein the step of regulating the operation of the drum (5) is performed during time periods of the tilting where
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- an absolute value of an inboard directed torque (M_d) induced by the pile's (10) weight, length and distance between the upper pile end (10a) and the abutting circumferential surface area, as well as the vessel's (200) movements due to environmental forces, is equal to, or near equal to,
 - 5 • an absolute value of a corresponding outboard directed torque (M_s).
18. The method in accordance with any one of claims 14 to 17, wherein the method further comprises the step:
- 10 • measuring a position of the upper pile end (10a) relative to an initial position in the laying orientation by measuring and/or calculating a length of the winch cable (8) between the drum (5) and a fixation point of the winch cable (8) on the upper pile end (10a) and a length of the crane cable (403) between a fixation point on the lifting crane (400) and a
 - 15 fixation point of the upper pile end (10a).
19. A computer-readable medium having stored thereon a computer program comprising instructions to execute the method steps of any one of claims 14 to 18.