

### CLAIMS

1. Device for controlling the movement of one of the ends of an articulated fluid loading arm from a storage position to a target pipe (35) and from this target pipe (35) to the storage position, said arm comprising  
5 a fluid transfer line equipped at this end with a coupling system (26), the latter being adapted to be coupled to the target pipe (35) for the transfer of the fluid, which device comprises actuators (27-29) for controlling the movement of the arm in space from the storage position until the coupling system (26) is positioned in front of the target pipe (35) for its coupling to  
10 the latter, and from the target pipe (35) to the storage position, and this device being characterized in that it includes calculation means (41) adapted for:

- monitoring in real time the movement of the coupling system (26);
- generating, in real time, from the last determined position of the  
15 coupling system (26) a trajectory of movement of the coupling system (26) in the direction of the target pipe (35) or the storage position, based on a dynamic jerk-limited motion law;
- calculating command instructions to be given to each of the actuators (27-29) in order to control the movement of the coupling system  
20 (26) based on this motion law.

2. Device according to claim 1, characterized in that the step for real-time monitoring of the movement of the coupling system (26) involves a real-time monitoring, during at least part of the movement, of the relative  
25 position of the coupling system (26) with respect to the target pipe (35), the trajectory being generated from the last determined relative position.

3. Device according to claim 2, characterized in that the step for real-time monitoring of the relative position of the coupling system (26)  
30 with respect to the target pipe (35) also involves a real-time monitoring of the relative orientation of the coupling system (26) with respect to the

target pipe (35), the trajectory being generated based on the relative position and the relative orientation that were last determined.

5           4. Device according to any of claims 1 through 3, characterized in that when the target pipe (35) is installed on a floating structure, and the loading arm is installed on a fixed or floating structure, the calculation means are linked to measurement means for the real-time monitoring of the absolute or relative movements of the floating structure or structures in all 6 degrees of freedom simultaneously.

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          5. Device according to claim 4, characterized in that the measurement means are chosen from the group comprising inertial units, GPS, GPS adapted to perform relative position monitoring, cameras, inclinometers, accelerometers, potentiometers, sonar, laser trackers, 15       tacheometers, or a combination thereof.

          6. Device according to any of claims 1 through 5, characterized in that the calculation means comprise prediction functions adapted for predicting (i) the progress of the movement of the coupling system (26) 20       and/or (ii) the behavior of the articulated loading arm in relation to the dynamic jerk-limited movement command that is applied to it; and are adapted for adjusting the dynamic jerk-limited motion law so that it takes the prediction into account.

25           7. Device according to any of claims 1 through 6, characterized in that the calculation means use, for the monitoring, a kinematic model of the arm that compensates for real dimensional, deformation, and/or position errors.

30           8. Device according to claim 7, characterized in that the kinematic model of the arm is obtained by a calibration procedure and an adjustment of the parameters of a model of the loading arm incorporating these errors.

5 9. Device according to claim 8, characterized in that the adjustment is performed by means of nonlinear optimization algorithms, or by training a neural network, using measurements obtained by the calibration procedure.

10 10. Device according to any of claims 1 through 9, characterized in that the calculation means are adapted to apply command instructions to each of the actuators (27-29) so that the movement induced by each of the actuators is simultaneous and has the same duration.

15 11. Device according to any of claims 1 through 10, characterized in that the calculation means are adapted to apply command instructions for maintaining jerk-limited motion in the various modes of control, i.e. automatic, or manual by the operator via a command interface, or a semi-automatic mode combining the manual and automatic commands.

20 12. Device according to any of claims 1 through 11, characterized in that the control device also includes active vibration damping means, adapted to superimpose a vibration set point on the command instructions applied to the actuators (27-29).

25 13. Device according to any of claims 1 through 12, characterized in that the calculation means are also adapted to generate the trajectory so as to avoid collisions between the arm and an element or structure in the surroundings.

30 14. Data acquisition and calculation device (41) for a device according to any of the preceding claims, characterized in that it is adapted for:

- monitoring in real time the movement of the coupling system;

- generating, in real time, from the last determined position of the coupling system, a trajectory of movement of the coupling system in the direction of the target pipe or the storage position, based on a dynamic jerk-limited motion law;

- 5                   - calculating command instructions to be given to each of the actuators in order to control the movement of the coupling system based on this motion law.

10               15. Calculation method for a data acquisition and calculation device according to the preceding claim, characterized in that it comprises the computing steps consisting of:

- monitoring in real time the movement of the coupling system;
- generating, in real time, from the last determined position of the coupling system, a trajectory of movement of the coupling system in the direction of the target pipe or the storage position, based on a dynamic jerk-limited motion law;
- 15                   - calculating command instructions to be given to each of the actuators in order to control the movement of the coupling system based on this motion law.

20               16. Method according to claim 15, characterized in that it also comprises the steps consisting of predicting (i) the progress of the movement of the coupling system and/or (ii) the behavior of the articulated loading arm in relation to the movement command that is applied to it, and

25                   adjusting the dynamic jerk-limited motion law so that it takes the prediction into account.

30               17. Articulated loading arm comprising a fluid transfer line equipped at one of its ends with a coupling system adapted to be coupled to a target pipe, and a control device according to any of claims 1 through 13.