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Ships and marine technology — Jacking system appliances on self-elevating unit — Rack pinion leg fixation system

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 4, *Outfitting and deck machinery*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Ships and marine technology — Jacking system appliances on self-elevating unit — Rack pinion leg fixation system

1 Scope

This document specifies requirements on the composition, classification, equipment, inspection, testing, designation, marking and documentation for the rack pinion leg fixation system of a self-elevating unit.

This document is applicable to the design, manufacture, inspection and acceptance of leg fixation systems of self-elevating units.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 3662, *Hydraulic fluid power — Pumps and motors — Geometric displacements*

ISO 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

IEC 60079-1, *Explosive atmospheres — Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60092-301, *Electrical installations in ships — Part 301: Equipment — Generators and motors*

IEC 60092-302-2, *Electrical installations in ships — Part 302-2: Low voltage switchgear and controlgear assemblies — Marine power*

IEC 60092-360, *Electrical installations in ships — Part 360: Insulating and sheathing materials for shipboard and offshore units, power, control, instrumentation and telecommunication cables*

IEC 60529, *Degrees of protection provided by enclosures (IP code)*

IACS Rec. No.68, *Guidelines for non-destructive testing of hull and machinery steel forgings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
self-elevating unit
mobile offshore unit with movable legs capable of raising its hull above the surface of the sea and lowering it back into the sea

3.2
rack pinion leg fixation system
leg fixation system
mechanical system to keep the hull of a *self-elevating unit* (3.1) and legs stationary, where the unit is in the elevated or the afloat condition

Note 1 to entry: Its main function is to establish a rigid connection between the hull and the pile legs by meshing and fixing the *rack chocks* (3.4) with the pile leg racks after elevating the self-elevating unit or legs.

3.3
vertical design load
maximum working load that the *leg fixation system* (3.2) is able to withstand continuously in the vertical direction

3.4
rack chock
important load which, during locking operation, is pushed by a power unit, engaged and fixed with pile leg racks, and can withstand the pile leg supporting force and transfer the force to the unit hull through the mechanical fixation mechanism, so as to keep rigid connection between hull and the pile legs

4 Composition and classification

4.1 Composition

4.1.1 The leg fixation system mainly includes the mechanical fixation mechanism, power unit and control system.

4.1.2 The mechanical fixation mechanism generally includes the rack chock, screw and nut, wedge block (top/bottom, if any) and hydraulic cylinder.

4.1.3 The power unit is generally divided into an electric power unit and hydraulic power unit. The electric drive unit generally includes an electric motor and electromagnetic brake, while the hydraulic drive unit generally includes a hydraulic motor and hydraulic pump station.

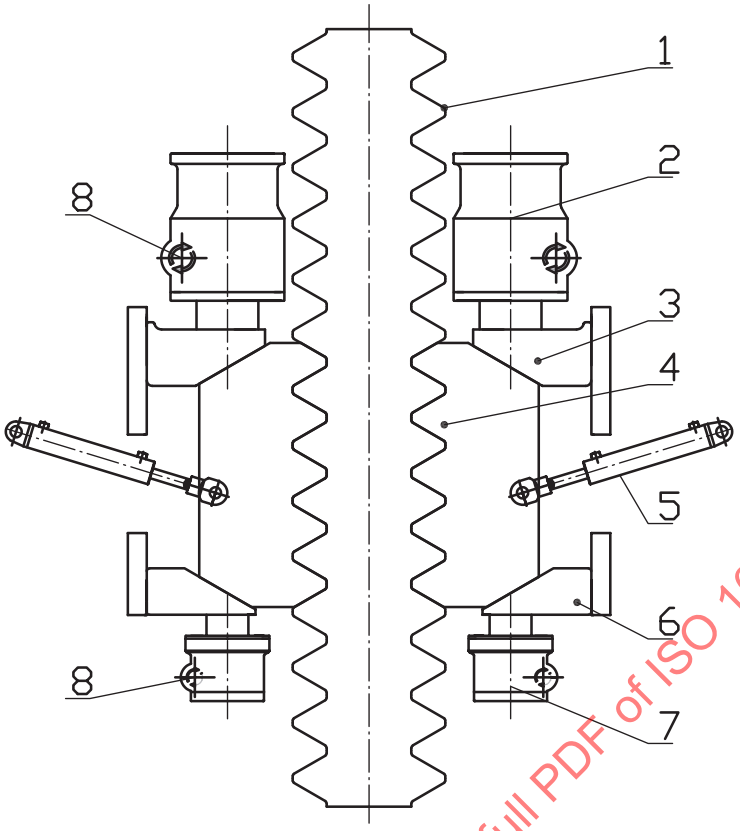
4.1.4 The control system generally includes the main control system, sub-control system and remote-control box.

4.2 Classification

4.2.1 The leg fixation system is divided into two types according to the structural types.

a) Type A — leg fixation system with wedge blocks; see Figure 1.

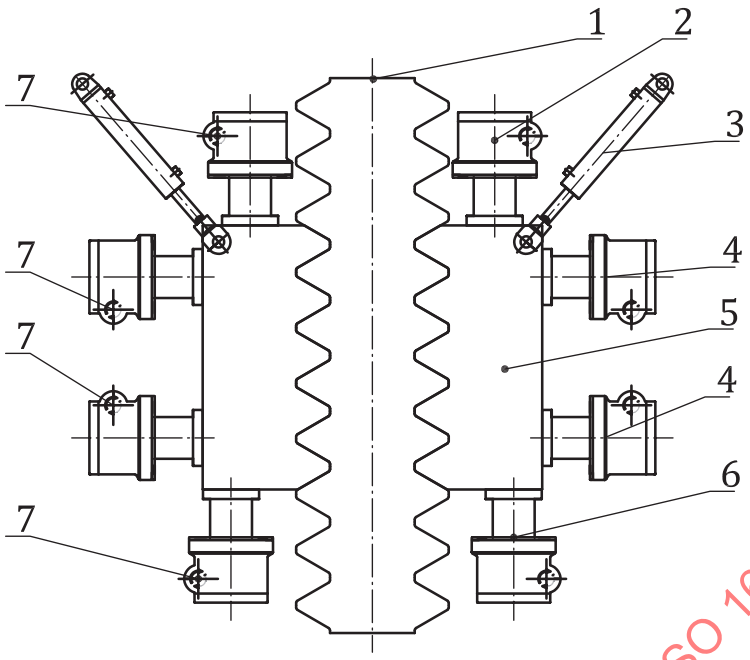
b) Type B — leg fixation system without wedge block; see Figure 2.



Key

1 pile leg rack
2 screw and nut (top)
3 wedge block (top)
4 rack chock
5 hydraulic cylinder
6 wedge block (bottom)
7 screw and nut (bottom)
8 electric/hydraulic motor

Figure 1 — Schematic diagram of Type A leg fixation system (with wedge blocks)



Key

1 pile leg rack
2 screw and nut (top)
3 hydraulic cylinder
4 screw and nut (side)
5 rack chock
6 screw and nut (bottom)
7 electric/hydraulic motor

Figure 2 — Schematic diagram of Type B leg fixation system (without wedge block)

4.2.2 The leg fixation system is divided into following two types according to the driving mode:

a) Type E — leg fixation system with electric power unit.

b) Type H — leg fixation system with hydraulic power unit.

5 Technical requirements

5.1 Design requirements

5.1.1 The leg fixation system shall be designed and constructed with failure mode and effect analysis (FEMA) to ensure a certain level of redundancy, so that a single failure of any component of the leg fixation system will not damage the safety of the unit. The leg fixation systems should be provided with self-fixation means to safely maintain the relative height of the legs of the unit in case of loss of power (e.g. electric, hydraulic or pneumatic).

5.1.2 Strength analysis of leg fixation system shall at least include the maximum load, under the following conditions:

a) normal holding of unit;

b) normal holding of pile legs; and

c) severe storm holding of unit (i.e. elevating and afloat conditions).

5.1.3 The rack chock shall be designed as follows:

a) Under static condition, the ultimate strength (collapse load) of the rack chock tooth root shall not be less than 1,1 times that of the (pile leg) rack tooth root;

b) Material of rack chock shall have sufficient capacity, and the design may comply with the requirements of applicable classification society specifications.

NOTE Material hardness of the rack chock is generally not less than that of the pile leg rack.

5.1.4 The electric power unit shall be provided with safety devices or measures to prevent power overload.

5.1.5 The hydraulic power unit shall be provided with safety devices or measures to prevent the working pressure from exceeding the design pressure.

5.1.6 The hydraulic cylinder structure shall be designed to sufficiently consider its safety, reliability and adaptability to the working environment.

5.1.7 The control station from which the fixation gear machinery is operated shall be provided with all necessary monitoring, alarms and controls, including voltage, current, liquid level, running indication, sound and light alarms and indication of the availability of applicable power units, as appropriate.

5.1.8 The control system shall be able to display the working state of complete locking and complete disengagement of the mechanical fixation mechanism.

5.1.9 The overall dimensions of the leg fixation systems shall be designed to adapt to the installation position on the self-elevating unit, where the structural strength shall meet at least the maximum static load that the leg fixation systems can withstand.

5.1.10 The leg fixation system shall be protected against corrosion and the leg fixation system shall be kept well lubricated.

5.1.11 The leg fixation systems shall be designed to keep its electrical interface, hydraulic interface and lubrication interface well connected with the unit.

5.1.12 The new designed systems shall be type tested by the manufacturers to verify relevant design performance.

5.2 Mechanical fixation mechanism

5.2.1 Materials of main components of fixation mechanism shall be selected in accordance with the service load environment, purposes and design temperature. These materials should also be selected according to Table 1.

Table 1 — Material of main components of the leg fixation system

Components name	Material	
	Material name	Applicable standard
Rack chock, wedge block, screw, cylinder barrel, piston rod	Alloy structural steel forgings	ASTM A668
Nut	Copper alloy	ASTM B824

5.2.2 The materials of the main components of the fixation mechanism may be specified by tensile strength, yield strength and impact performance in the design drawings. Other materials with a performance not lower than those specified in Table 1 may be used.

5.2.3 The outer and inner surface of the materials of the main components of the fixation mechanism should be flat and smooth, without obvious cracks, pores, scars, interlayers, folds and other material defects that can affect the structural strength. The general acceptance level of the materials shall not be lower than the level II or an equivalent acceptance level specified in IACS Rec. No.68, except for other acceptance level requirements proposed by the design.

5.2.4 The dimensions of the main components of the fixation mechanism shall comply with specifications of the design drawings.

5.2.5 The tooth profile of the rack chock should match the leg racks. It is recommended that the number of the teeth is not less than 3. The thickness of the rack chock shall not exceed two times the thickness of pile leg rack.

5.2.6 The contact surface between the wedge block and rack chock shall be supplied with a suitable lubricant during all operations.

5.2.7 The fixation mechanism driven by screws and nuts during the locking and unlocking operation should be provided with grease fillers to facilitate regular filling and renewal of lubricating grease.

5.2.8 The cylinder barrel and piston rod of the hydraulic cylinder shall not be made of cast materials. All components in the cylinder that are in contact with the working medium (such as hydraulic oil) shall be made of materials avoiding corrosion and chemical action with the working medium.

5.2.9 The hydraulic cylinder shall operate stably without stagnation, vibration and crawling.

5.2.10 The hydraulic cylinder shall be able to withstand sufficient pressure up to 1,5 times the design pressure. There should be no damage or permanent deformation in the main components, no leakage at the sealing and weld lines, and no external leakage at the joint surface of components.

5.2.11 The fixation mechanism shall be designed so that each device can be inspected, repaired and replaced independently. Its working space should be well illuminated and provided with safe access for maintenance.

5.2.12 The parts of the fixation mechanism which are installed in open air or in contact with seawater may be coated or plated for corrosion prevention. The coating or plating shall be free of pinholes, pits, peeling, blistering and flaking. The thickness of coating or plating shall comply with the specifications of the design drawings.

5.3 Power unit

5.3.1 If the power unit uses electricity as the power source, the motor shall comply with IEC 60092-301, the IP protection grade shall reach IP56, the insulation grade shall reach F, and the braking torque of electromagnetic brake shall be selected to ensure a sufficient safety factor.

5.3.2 If the power unit uses hydraulic pressure as the power source, the selection of hydraulic motor shall comply with ISO 3662, and the design of hydraulic pump station shall comply with ISO 4413.

5.3.3 The hydraulic piping system of the power unit shall generally use a galvanized seamless steel pipe or a stainless steel pipe.

5.3.4 The hydraulic pipes shall be tightly connected to ensure the interfaces of the hydraulic piping system free of leakage.

5.3.5 The hydraulic pipe shall have a sufficient pressure resistance to withstand 1,5 times the design pressure and the hydraulic piping system shall be free of leakage. In any case, the test pressure shall not exceed 85 % of the material yield strength.

5.3.6 The hydraulic pipe shall be arranged parallel or vertically, to avoid bending and cross connection as far as possible.

5.3.7 The hydraulic pump station shall be equipped with a device that can discharge all the hydraulic oil, and a filter/device which enables maintenance in front of the pump.

5.3.8 The hydraulic pump station shall keep oil temperature generally from 0 °C to 60 °C and shall have a low-temperature alarm display and heating function when lower than 0 °C. It shall have a high-temperature alarm display and cooling function when higher than 60 °C.

5.4 Control system

5.4.1 General requirements

5.4.1.1 The low voltage switch gear and control equipment shall comply with IEC 60092-302.

5.4.1.2 The cables shall comply with IEC 60092-360.

5.4.1.3 The protection grade of the electrical equipment shell shall meet the requirements of waterproof and dustproof equipment in the operation area. The electrical equipment above the deck shall have an IP protection not lower than IP56 as specified in IEC 60529.

5.4.1.4 The explosion-proof grade of an electrical equipment shell or an element shall meet the requirements of the operation area and the explosion-proof requirements specified in IEC 60079-1, when control system is installed in an explosion-proof area.

5.4.2 Main control system

The main control system is a control centre responsible for all fixation mechanisms and power units of every single pile leg. It monitors and collects various actions and alarm signals of the fixation mechanism and power unit, and is connected with the sub-control system by cables. The main control system shall meet the following requirements:

a) It shall have the function of monitoring the locking and unlocking the operation of the fixation mechanism and the working status of power unit.

b) It shall have the function of sound and light alarms in case of dangerous states or abnormal working conditions including overload, over limit, etc. Specific alarm information can be queried through the display. For the hydraulic power unit, there shall also be alarms for low oil level, low oil temperature, high oil temperature and filter blockage.

c) The indicator, instrument or display shall be provided with correct indication and reliable operation.

d) Each button, switch, indicator light and display shall be labelled.

e) The main control system shall have a separate power supply.

5.4.3 Sub-control system

The sub-control system has built-in logic commands for the actions of the fixation mechanism and power unit to control each set of fixation mechanism and driving unit separately. The sub-control system may be arranged beside legs and near the fixation mechanism to enable the operator to observe the operating state of the fixation mechanism. The sub-control system:

a) can monitor the working status of fixation mechanism and power unit, send alarm in case of emergency, and send signals to main control system;

b) should be provided with indicator lights, instruments or displays to ensure correct indication and reliable operation;

c) shall have handles, buttons, switches, indicator lights and displays which are equipped with labels.

5.4.4 Remote control box

The remote control box is a portable control device for operating the fixation mechanism and power unit. It can be quickly connected with the sub-control system through cables to facilitate the operator to carry and operate on site. The remote control box:

a) shall be equipped with operation buttons to control the operation of the fixation mechanism and power unit;

b) should be provided with indicator lights, instruments or displays to ensure correct indication and reliable operation;

c) shall have handles, buttons, switches, indicator lights and displays equipped with labels.

6 Inspection and testing

6.1 Inspection

6.1.1 Material

Inspection of the materials of the main components of the fixation mechanism shall be carried out in accordance with ISO 6892-1 and ISO 148-1. The results of this inspection should comply with 5.2.2.

6.1.2 Surface/internal quality

The surface/internal material quality of the main components of the fixation mechanism shall be inspected according to the non-destructive testing method specified in IACS Rec. No. 68. Appearance quality shall be checked by visual inspection. The results of this inspection shall comply with 5.2.3.

6.1.3 Dimensions

The dimensions of main components of the fixation mechanism shall be tested in accordance with the design drawings, and suitable measuring tools or testing instruments shall be selected. The results of this inspection shall comply with 5.2.4.

6.1.4 Coating/plating

The coating/plating surface of main components of the fixation mechanism shall be checked by visual inspection for burrs, bumps, scratches, rust marks and pinholes, pitting, peeling, blistering and peeling. The coating/plating thickness can be measured by the coating/plating thickness gauge, and shall comply with 5.2.12.

6.2 Testing

6.2.1 Test arrangement

6.2.1.1 Before the test, the instruments, equipment and wiring should be checked to ensure it is in good condition, and that the protective devices of the equipment and lines work smoothly and have good insulation.

6.2.1.2 During the test, necessary safety protection measures shall be taken for test personnel, and isolation measures or warnings shall be taken at the test site.

6.2.1.3 The test shall be carried out according to the compiled testing programme of the leg fixation system. Upon completion of the test, a test report and relevant technical documents shall be submitted by the manufacturer.

6.2.2 Pressure test

6.2.2.1 The pressure test for the hydraulic cylinder of the fixation mechanism shall be performed as follows:

a) Pressure test with no load: the hydraulic cylinder shall run at least three times in full stroke in no-load condition, and the results shall comply with 5.2.9.

b) 1,5 times pressure test: with the piston rod holding at two stroke limit positions respectively, the test pressure shall be input to the working chamber of the oil cylinder to 1,5 times the design pressure, holding for at least 5 min, and the results shall comply with 5.2.10.

6.2.2.2 The pressure test for the hydraulic pipe shall be conducted as follows:

a) Tightness test: after the pipe is connected, seal the outlet at one end of the pipe, gradually pressurize from the other port to 1,25 times the design pressure, and hold the pressure for at least 5 min. The results shall comply with 5.3.4.

b) Pressure test: after the pipe is connected, seal the outlet at one end of the pipe, gradually pressurize from the other port to 1,5 times the design pressure, and hold the pressure for at least 5 min. The results shall comply with 5.3.5.

6.2.3 Safety protection testing

6.2.3.1 Alarm test

Safety protection tests are conducted by inputting analogue signals to the control system of the leg fixation system. The test contents include but are not limited to: motor high temperature alarm, motor overcurrent alarm, motor overload alarm, low liquid level alarm, low oil temperature alarm, high oil temperature alarm, system overpressure alarm, position limit alarm and fault alarm. The main control system shall be provided with corresponding alarm lights or buzzer alarms.

6.2.3.2 Emergency stop test

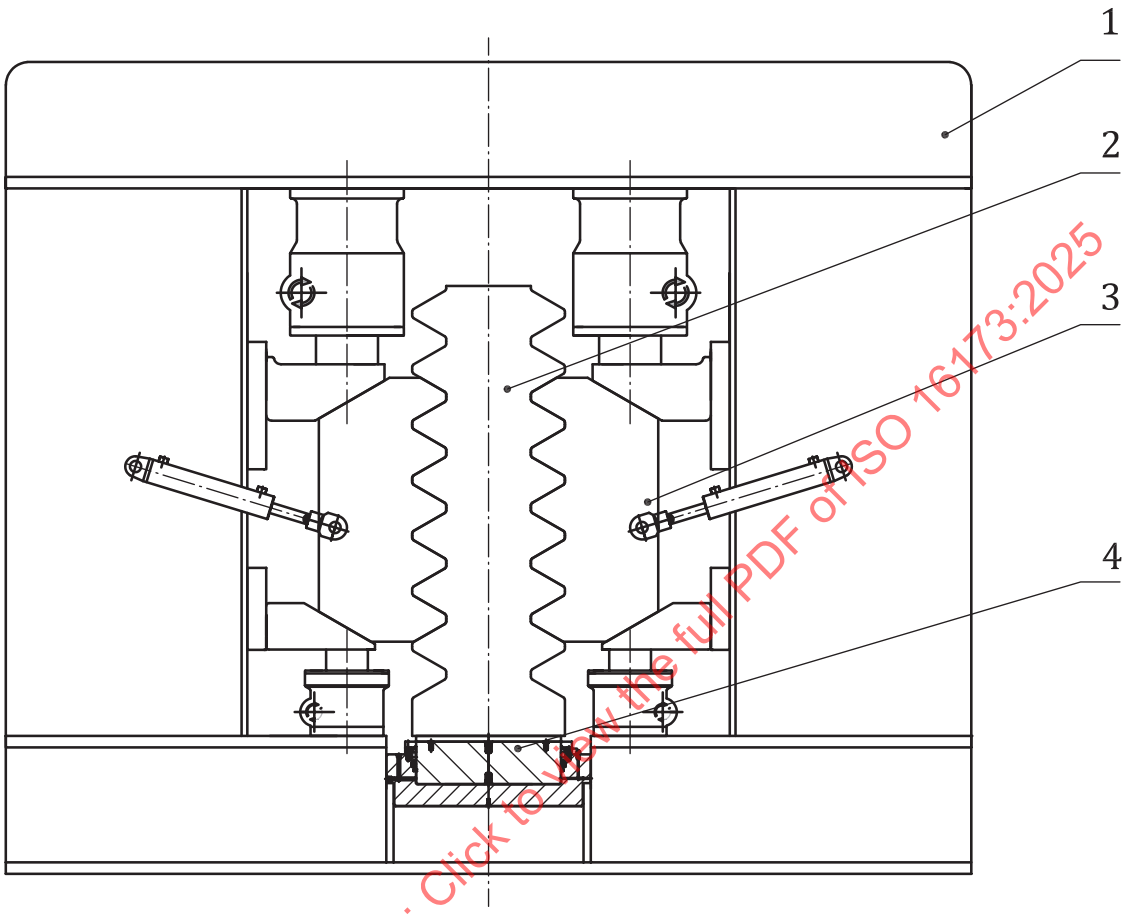
Press the emergency stop button of the leg fixation system in the simulated emergency condition. The system shall stop working and all operation buttons shall be invalid.

6.2.4 Locking and unlocking test

During the test, the leg fixation system shall be installed on the testing machine (see Figure 3). Then, the hydraulic cylinders are operated to push the rack chocks to engage with the simulated pile leg racks and the screw nuts are operated to push the wedge block to fit with the rack chock.

The unlocking test starts after the locking test is completed. The hydraulic cylinders are operated to pull back the rack chocks to separate from the simulated pile leg racks, and the screw nuts are operated to drive the wedge block to separate from the rack chock.

During the test, the fixation mechanism shall perform accurately throughout the process, and the results shall comply with the testing programme.



Key

1 testing machine
2 simulated pile leg rack
3 rack chock
4 simulated load cylinder

Figure 3 — Schematic diagram of leg fixation system test

6.2.5 Static load bearing capacity test

6.2.5.1 During the type testing, the locking operation shall be carried out first, then the test shall be performed with the following steps, by gradually loading upon the simulated pile leg rack through the simulated load cylinder at the bottom of the testing machine:

a) Slowly and uniformly increase the pressure on the fixation mechanism up to 35 % of the vertical design load, and hold for at least 5 min;

b) Slowly and uniformly increase the pressure on the fixation mechanism up to 70 % of the vertical design load, and hold for at least 5 min;

c) Slowly and uniformly increase the pressure on the fixation mechanism up to 110 % of the vertical design load, and hold for at least 5 min;