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# **SWING BRIDGE REPLACEMENT, BERMUDA APPROVAL IN PRINCIPLE – M&E**

## SWING BRIDGE REPLACEMENT, BERMUDA APPROVAL IN PRINCIPLE – M&E

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### Appendix 1

Technical Approval Schedule (TAS)

## 1. HIGHWAY DETAILS

### 1.1 Type of highway

Road, pedestrian and cycle bridge.

### 1.2 Permitted traffic speed

Road over: 31mph (50 km/h)

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## 2. STRUCTURE DETAILS

### 2.1 Brief description of structure

The proposed new structure spans between Ferry Reach and Stocks Harbour and provides motorist and pedestrian connectivity between St. David's Island and St. George's.

The lift span comprises a main steel box girder with a curved soffit that has a deep main spine, which tapers toward the edges of the box, resulting in slender wings that project beyond the pedestrian footpath into a crescent opening.

In the closed position (i.e. road traffic allowed to cross) the structure is supported on the main pier by two radial spherical bearings and is supported on two elastomeric bearings on the nose pier. In this condition, in order to resist the upward load of wave action a pair of nose locking pins is provided.

In the open condition (i.e. to allow marine traffic to pass), the system acts as a cantilever supported on the hydraulic cylinders and trunions at the east abutment.

### 2.2 Date of the AIP for structure

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## 3. GENERAL DESCRIPTION OF MECHANICAL AND ELECTRICAL INSTALLATION (M&E)

### 3.1 Proposed mode of operation of structures

The bridge is lifted by a pair of large diameter hydraulic cylinders mounted in front of the pivot bearing at the main pier and close to the centre line of the bridge. In any position other than fully lowered, the bridge is supported on the pivot bearings and the hydraulic cylinders.

The speed of bridge movement is controlled by a programmable logic controller (PLC). To bring the bridge to a controlled stop in the fully lowered position vertically orientated shock absorbers will be located on the nose pier. The elastomeric bearing pads will provide a support which will enable the alignment pin to be inserted without requiring that the pin must move the deck to achieve correct location.

### 3.2 Location of operating and control mechanism

The hydraulic power pack and associated electrical control equipment will be housed in a dedicated plant room in the south abutment. The plant room will comprise large opening doors and a parking area to maximise the ability to remove equipment if necessary.

Automated barriers will be located on the static approaches at both ends of the moving span.

These barriers, a warning klaxon and traffic signals will control traffic and pedestrian access onto the bridge prior to, and during bridge movements. The duration of the warning klaxon will be adjustable.

The bridge will be operated from a dedicated control room located on the north abutment of the existing swing bridge. The operator interface in the control building will comprise a control desk equipped with the following physical control buttons to operate the bridge:

- ACTIVATE BRIDGE (key switch)

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- START WARNING SOUNDERS AND SIGNALS (illuminated push button)
- CLOSE NORTH EXIT BARRIER (illuminated push button)
- OPEN NORTH EXIT BARRIER (illuminated push button)
- CLOSE SOUTH EXIT BARRIER (illuminated push button)
- OPEN SOUTH EXIT BARRIER (illuminated push button)
- CLOSE NORTH ENTRY BARRIER (illuminated push button)
- OPEN NORTH ENTRY BARRIER (illuminated push button)
- CLOSE SOUTH ENTRY BARRIER (illuminated push button)
- OPEN SOUTH ENTRY BARRIER (illuminated push button)
- RAISE BRIDGE (illuminated push button)
- LOWER BRIDGE (illuminated push button)
- EMERGENCY STOP
- EMERGENCY STOP RESET (spring return key switch)
- FAULT (lamp)

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To guide the operator during the opening and closing process, each control button will be illuminated when that action can be carried out.

Additional feedback from the bridge control system will be provided by messages display on a Human Machine Interface (HMI) next to the control buttons. The HMI will provide feedback and equipment status messages to enable any potential issues to be diagnosed and rectified promptly. CCTV cameras will be located to monitor critical areas of the bridge to enable safe operation and observer bridge users during bridge movements. The signals from the CCTV system will be displayed on screens next to or above the bridge control interface.

CCTV outline specification document will be provided during the detailed design stage for final design and build by local CCTV contractor.

A wired pendant will be provided to operate the bridge in maintenance mode. The pendant shall have the following controls (as a minimum):

- EMERGENCY STOP (push button) (red, latching, twist to release)
- Barriers (three position selector switch) (north / both / south)
- Barriers (three position selector switch) (entry / both / exit)
- Open barriers (push button)
- Close barriers (push button)
- Nose locking pin 1 (three position spring to centre switch) (extend / 0 / retract)
- Nose locking pin 2 (three position spring to centre switch) (extend / 0 / retract)
- RAISE bridge (illuminated push button)
- LOWER bridge (illuminated push button)
- WARNING SOUNDERS AND SIGNALS (three position spring to centre switch) (start / 0 / stop)

Position sensors will monitor the bridge position throughout the range of movement and at the limits of travel. The position of the bridge and the sequence of operation will be controlled by the interlocks within the PLC control system. Multiple position sensors will be provided to allow the control system to identify if a sensor has failed.

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Marine traffic control signals will not be provided. Red and green port and starboard lights will be mounted on either edge of the bridge. Additionally three air draft lights per edge (colour to be confirmed) will be provided on the bridge soffit to advise of navigation clearance during night hours.

A black buoy/flag will be mounted on a post located at the bridge operator hub to indicate to the boats that the bridge will not operate anymore that day.

Signs communicating opening hours will be located on the substructure.

### 3.3 Electrical power supply and distribution

The main incoming power will be stepped down to low voltage (LV) and installed into the plant room by the electricity supply company. The LV supply will be supplied to a switched point from

which a distribution panel will supply power the various equipment associated with bridge operation.

**3.4 Stand-by-power facilities (UPS etc.)**

No back-up power facilities are proposed.

**3.5 Design working life, whole life cost and sustainability considerations**

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The bridge is not opened very frequently and it will be designed for 2920 operations per year, based on a maximum of 8 operations per day and a maximum short-term frequency of 2 movement per hour. The mechanical equipment will be designed for the life (subject to regular preventative maintenance and inspection) shown in Table 1.

**Table 1 – Design working life for the mechanical equipment**

Fabrications for the mechanical components inc. pivot housings and cylinder mounting brackets	75 years
Replaceable mechanical items (e.g. bearings, bushes)	50 years – anticipated that pivot and cylinder bearings will have a significantly higher theoretical life
Electrical equipment	15 years
Hydraulic equipment – major items such as power pack and cylinder/ rod main components	25 years
Hydraulic equipment – pipework	25 years
Hydraulic equipment – minor items such as seals	15 years
Hydraulic equipment – hoses	7 years

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The mechanical equipment will be designed with the aim of minimising maintenance and adjustment requirements. The pivot and cylinder mounting bearings will be specified as maintenance free. Additional lubrication will extend the life of the bearing and aid with corrosion protection.

**4. OPERATIONAL DESIGN CRITERIA (AS RELEVANT)**

**4.1 Variable actions**

Refer to Structural AIP (Document number 3502-RAM-SB-XX-RP-CB-30001).

**4.2 Traffic actions**

Refer to Structural AIP.

**4.3 Snow actions**

Refer to Structural AIP.

**4.4 Wind actions**

For wind actions in road open position refer to Structural AIP.

For bridge movement with both rams functioning, the maximum operating speed shall be 15.64m/s (35mph). A higher wind speed of 20.11m/s (45mph) will be used for design purposes to provide a safety margin.

For the bridge movement with a single ram functioning, the maximum design wind speed shall be 8.05m/s (18mph). A reduced buckling safety factor of 3.0 is to be applied under this loading condition.

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For the assessment of the fatigue loading on M&E components 50% of the longitudinal operating wind load shall be considered in combination with dead loads to calculate the range of loads during a lifting cycle.

An additional extreme wind load condition shall be considered in the design of M&E components. This case is intended to allow for the extreme event where the bridge has been opened, or partly opened, under the normal twin ram conditions but becomes inoperable due to some fault condition, and then wind gusts speeds increase above the normal operating limit, the wind speed for this condition shall be taken as 24.6m/s (55mph). This condition does apply to single ram operation. This will be assessed as a fault case in accordance with the crane code as loading condition Case 4. A reduced buckling safety factor of 3.0 is to be applied under this loading condition.

#### 4.5 Thermal actions including temperature range

Refer to Structural AIP.

#### 4.6 Any Special actions not listed above (e.g. ship impact)

- Ship impact - Refer to Structural AIP.
- A load combination is required to address the lift span opening case with only dead loads present. This load combination shall use  $\gamma_{FL ULS} = 1.30$  on structure dead loads (which is composed by a 1.1 factor due to uncertainty on the weight of the structure and an additional 1.2 factor to include for dead load dynamic load allowance).
- Loads due to emergency stop. The safe stopping of the bridge and the limiting loads that can be applied to the structure will be the determining factor when deciding upon the speed of the emergency stop.
- Loads imposed by fault operation of the system. Failure scenarios highlighted by the Failure Mode Effect Analysis (FMEA) will be considered during the detailed design.
- In addition to the dead, wind and snow factors the loads for sizing the hydraulic cylinder will have a factor of 1.2 applied to account for dynamic behaviour of the hydraulic system and to ensure adequate sizing of equipment such that it is not running at full capacity.
- The anchor bolts connecting each mechanical components to the civils works will be preloaded up to 40% of their ultimate tensile stress to allow for removal and replacement of equipment with the same cast in anchors.

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#### 4.7 List of relevant Safety Consultation documents

##### 4.7.1 Additional relevant standards and publications

Mechanical and structural elements of the operating equipment:

- BS 2573 Rules for the design of Cranes, Parts 1 (structures) and 2 (mechanisms)
- Based on the number of openings per year and the operating time, the Class of Utilisation of the mechanisms will be T7 (12 000 hours < mechanical life (hours) < 25 000 hours). The majority of load on the drive system will be due to dead load, hence the State of Loading (BS 2573-2, Table 2) will be L3.
- Using T9 and L3 for the drive system gives a Group Classification of M8.
- The Machinery Directive 2006/42/EC and referenced standards

Hydraulic Equipment:

- PD 5500:2018 "Specification for Unfired Fusion Welded Pressure Vessels"
- The test pressure shall be used as the design pressure for the cylinder.
- Strut buckling in accordance with BS 2573 Rules for the design of Cranes, Parts 1 (structures)
- Other hydraulic equipment by the use of first principles and in accordance with industry best practice

Electrical equipment:

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- The Machinery Directive 2006/42/EC and referenced standards including the requirements for preparing a CE mark for the equipment.
- Low Voltage Directive (Electrical Equipment Safety Regulations)
- Electromagnetic Compatibility (EMC) Regulation
- Council directive 92/57/EEC (Construction Design & Management) Regulations
- In accordance with BS7671 Requirements for Electrical Installations, IEEE Wiring Regulations (Edition current at time of machine being first put to use)
- The Waste Electrical and Electronic Equipment (WEEE) Directive
- BS EN 62305-1 :2006, Protection against Lightning, General Principles
- BS 7430:1998, Code of Practice for Earthing

Control System:

- In accordance with first principles and industry best practice

#### 4.8 **Proposed Departures relating to departures from Standards given in 4.7 and 4.7.1**

None anticipated.

#### 4.9 **Proposed Departures relating to methods of dealing with aspects not covered by Standards in 4.7 and 4.7.1**

N/A

## 5. BASIS OF OPERATION AND CONTROL

### 5.1.1 Normal operation conditions

Excluding the time taken to clear the bridge of traffic and pedestrians and to lower the barriers, the total operating time to be 360 seconds; it is proposed that this is split into a 180 second period for raising of the bridge and 180 second period for lowering. The final split of time between opening and closing period will be defined during the detail design.

When the bridge is fully lowered and open to road traffic, the equipment is in the following state:

- Deck fully lowered
- Nose locking pins inserted
- Control system inactive
- Electric motors to drive hydraulic pumps off
- Cylinders fully retracted and in float mode
- Traffic barriers open
- Warning lights and sounders off/ extinguished

Proposed normal operating sequence for raising and lowering of bridge deck:

1. Bridge Operator checks wind-speed indicators. If safe to operate bridge, Operator activates the bridge control system using the ON key-switch in the control console.
2. Operator activates the bridge warning systems using the START WARNING SOUNDERS and SIGNALS button.
3. The Operator monitors the traffic via direct line of sight and CCTV. Once the traffic has come to a stop, the Operator presses the CLOSE NORTH ENTRY BARRIER and CLOSE SOUTH ENTRY BARRIER buttons.
4. The Operator continues to monitor the traffic via direct line of sight and CCTV. Once the bridge is clear of pedestrians and vehicles, the Operator presses the CLOSE NORTH EXIT BARRIER and CLOSE SOUTH EXIT BARRIER buttons.
5. Once all barriers are closed, the warning sounders stop. The operator presses the OPEN button. The nose locking pins are retracted.
6. The operator makes a final visual check that the bridge is clear and then re-presses and **holds** the OPEN button. The two lift cylinders begin to extend, causing the bridge to raise. The bridge accelerates from stationary to full speed.

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7. The control system senses that the bridge is almost at the fully raised position and slows the bridge to creep speed.
  8. Once the bridge has reached the fully raised position the control system stops the bridge.
  9. The Bridge Operator can release the OPEN push button.
  10. Marine traffic can pass the bridge. No marine traffic control signals are proposed.
  11. Once all marine traffic has passed the bridge, the Bridge Operator visually checks that the bridge is clear of marine craft and no further vessels are approaching the bridge.
  12. The Bridge Operator presses and holds the CLOSE push button.
  13. The bridge begins to lower, accelerating from rest to full speed.
  14. Upon reaching the nearly lowered position, the control system slows the bridge to creep speed.
  15. The bridge deck contacts the shock absorbers, which assist in controlling the speed at which the bridge deck contacts the structural bearing pads. The bridge deck comes to rest on the structural bearing pads before the shock absorbers bottom out.
  16. Once the fully lowered position is reached, the hydraulic cylinders continue to retract to ensure that they are disengaged from the bridge.
  17. Once the cylinders have reached their fully retracted position, the nose pins are re-inserted.
  18. The Bridge Operator can release the CLOSE button.
  19. Operator activates the bridge warning systems using the START WARNING SOUNDERS and SIGNALS button.
  20. The OPERATOR presses and **holds** OPEN NORTH EXIT BARRIER and OPEN SOUTH EXIT BARRIER.
  21. The operator presses and **holds** OPEN NORTH ENTRY BARRIER and OPEN SOUTH ENTRY BARRIER buttons.
  22. The traffic lights are set back to green, the warning sounders are stopped.
  23. The operator deactivates the system by removing the key.
- No remote control is proposed.

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#### 5.1.2 Automatic (interlock override) condition

Operates under the same conditions as Normal Operation above but with the ability to override basic interlocks. The list of interlocks that can be overridden shall be developed as part of the detailed design.

- Operable by a single trained/ authorised operator.
- Operable from local operator desk.
- Ability to override interlock **controlled by key switch (to be discussed)** issued to suitably trained and authorised operatives.

#### 5.1.3 Manual/Maintenance condition

- The method of operation used to position the bridge for maintenance purposes or if the control system is not working correctly.
- Used when there are faults which have been detected by the control system and which can not be overridden in automatic operation (for example hydraulic system faults).
- Operable by a team of appropriately trained operators in radio and intercom contact.
- Operable from a position close to the bridge, using a wired pendant only.
- The ability to operate in manual/maintenance mode controlled by a key switch issued to suitably trained and authorised operatives.

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#### 5.1.4 Emergency Recovery

In case of an emergency condition, in which the bridge stops in raised or partially raised position, the operator shall be able to lower the bridge by manually releasing the valves on the cylinders.

This is unlikely to be a quick process and in order to ensure that the procedure is carried out safely, will need assistance from someone with a good understanding of the hydraulic system.

#### **5.1.5 Traffic control and monitoring**

The pedestrian and traffic barriers are as shown on drawing 3502-RAM-SB-XX-DR-M-3006. Due to the anticipated low volume of pedestrian traffic each barrier will close off a pedestrian walkway and one side of road traffic (i.e. a total of four barriers will be provided, two at each end).

The traffic control barriers will be of the swinging type and actuated using a small hydraulic cylinder beneath a hatch in the walkway.

The CCTV system shall be colour and the feeds shall be sent to the control room. The cameras will monitor:

- The moving span
- Approach roads and footways
- Under the deck and navigation channel

#### **5.2 Authorities consulted**

Bermuda Government

#### **5.3 State any special requirements imposed during liaison with such authorities**

None.

#### **5.4 Describe communications system involved**

During the design phase communication with the authorities consulted: Phase 1 and 2 reports, meetings, email and telephone.

During bridge operation communication with the public:

- PA system between operator and public waiting at barriers.
- Intercom between plant room and control room.
- No dedicated PA or radio system for boat operators is proposed.
- Red and green port and starboard light for boats.
- Air draft lights for boats is proposed.
- Black buoy/flag on a post for boats.
- Opening hours signage at the substructure.

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#### **5.5 Design requirements for emergency works testing and site operating conditions**

Emergency stop buttons will be provided in the control room, in the plant room, in the cylinder pit, and on the control pendant. Pressing any of the emergency stop buttons, or any emergency situation detected by the control system, will result in the removal of power to the drive system. The position of all equipment will be held (load holding valves on cylinders) until the system is reactivated following the resetting of the emergency stop and the pressing of one of the control buttons. Warning lights will continue to function during this whole process.

#### **5.6 Fail safe operation safety systems, failure mode effect (FME) analysis**

The analysis will assess the general risks to the reliable operation of the bridge against probability of occurrence and result of failure. It will also consider the safety implications of failure and the required performance levels of equipment, redundancy and back-up systems. It is not intended that statistical analysis will be carried out on items of the assessment that do not have safety implications.

An initial review has highlighted:

- Multiple pump sets should be provided to accommodate a unit being out of operation due to failure or maintenance; it is acceptable for bridge to operate at reduced speed if a pump set requires repair.

- The emergency stop system will require a minimum performance level (PLr) of d (to BS EN ISO 13849-1) as shown in Figure 1. This level has been estimated on the following parameters:
  1. S, the severity of injury, is S2, ie Serious (normally irreversible injury including death).
  2. F, the frequency of exposure to the hazard, is F2, ie Frequent to continuous and / or exposure time is long.
  3. P, the possibility of avoidance, is P1, ie it is possible to avoid the hazard under specific conditions.

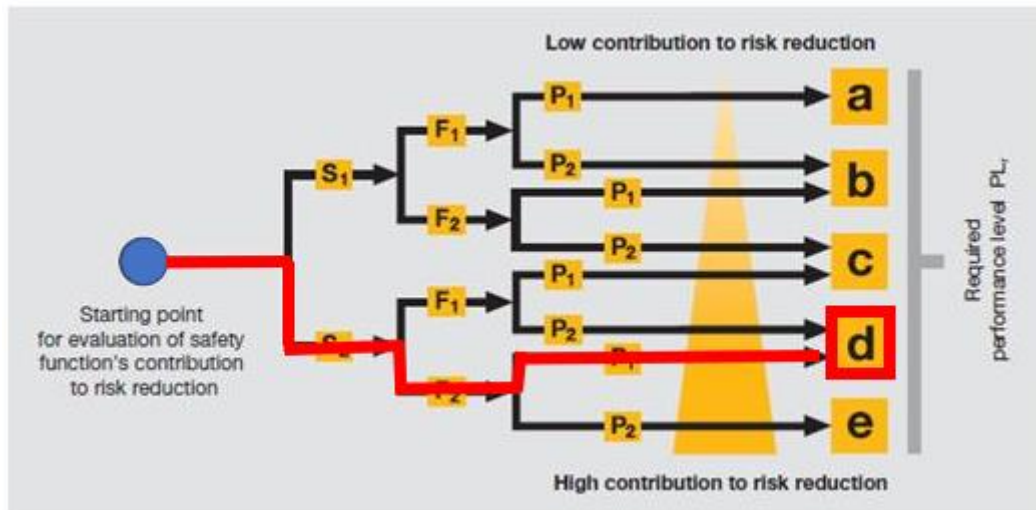


Figure 1 – Minimum performance level to BS EN ISO 13849-1

- The fully lowered position will be controlled by a pair of shock absorbers at the nose end of the bridge.

### 5.7 Arrangements for commissioning and handover to maintaining authority including relevant documentation and operators' manuals

#### Commissioning

- Record all commissioning activities.
- Test the emergency stop function.
- Begin to move the equipment in small increments, returning the equipment to the start position at the end of each increment. Gradually increase the size and speed of the increments as knowledge of the behaviour of the system increases.
- Test each part of the system under normal operation and check for compliance with the performance requirements.
- Test each part of the system under fault operation.
- Simulate faults.
- Test the recovery modes.
- Record normal and fault operating motor speeds, currents and voltages.
- Adjust equipment as required to ensure reliable and safe operation.
- Demonstrate compliance with the operating requirements to the satisfaction of the Project Manager.

#### Acceptance test

- The equipment will be operated by the Project Manager (or their representative) at will to test the system and verify the PLC logic.
- The operator will attempt to replicate reasonable or foreseeable mistakes in operating the equipment to check performance under fault scenarios.
- Attendance of the Contractor is required during the tests.

#### Documentation and O&M manuals

The following list of documentation is the minimum requirement for Project and Quality.

Documentation that should be provided for the whole of the mechanical and electrical supply.

- Quality records as outlined on the contractor's Quality Plan.
- Material Test Certificates in accordance with BS EN 10204 3.1b covering chemical, mechanical and physical properties
- NDT Certificates
- NDT Operator PCN approvals (note PCN level II operators)
- Heat Treatment Records
- Paint Records
- COSHH datasheets for all hazardous materials
- CE certification or declaration of incorporation

#### Other documentation

- Operating and Maintenance Manuals
- Detail Drawings
- Assembly Drawings
- Electrical circuit drawings, schematics and cabling layouts
- Hydraulic circuits, layouts and pipe details
- PLC program and operating software
- Panel Layout/GA drawings

#### O&M Manuals

The maintenance and operating manuals shall comprise the documents listed below.

Volume 1 - a purpose written document relating to the operation, maintenance and fault-finding system on the bridge. This document shall describe the following:

- General description of the mechanical, hydraulic and electrical equipment.
- Detailed description of the mechanical system and its operation, including a fault-finding chart based on an analysis of the effects of failure of each item of equipment and details of how to adjust each item of equipment.
- Detailed description of the electrical and hydraulic control systems and their operation, including a detailed description of the operation of the electrical and hydraulic circuits and a fault-finding chart. The fault-finding chart is to be based on an analysis of the effects of failure of each item of equipment. Details of how to adjust each item of equipment.
- Detailed description of each item of ancillary equipment and its operation:
  - Where items are specifically manufactured for this contract, the description shall include a detailed description of the operation of the equipment and a fault-finding chart. The fault-finding chart shall be based on an analysis of the effects of failure of each item of equipment.
  - Where items are proprietary equipment, the description shall include a detailed description of the application to this contract and a fault-finding chart. The fault-finding chart may be based on the manufacturer's fault-finding instructions but shall be comprehensive and specific to this contract.
- Description of operating procedures for all types of operation.
- Description of all maintenance operations and maintenance schedules, including greasing instructions.
- Recommended spares holding.
- Design information.
- Test certificates.
- Design & check certificates.
- Cables schedules and cable single line diagrams.

Volume 2 – Manufacturer's literature – a purpose written document incorporating manufacturers' literature for each significant component (mechanical, ancillary, electrical control or power) used on the contract. Including the following:

- A listing of all items of equipment including manufacturer, reference number, number of and location. For hydraulic equipment, these shall be cross-referenced to the parts list on the hydraulic circuit.
- A listing of all manufacturers and their addresses as referenced in the list of items.
- Manufacturer's reference literature to be supplied for each significant item. This shall include a cover sheet and manufacturer's maintenance information. Generally, copies of catalogue pages will not be satisfactory.
- All manufacturers' literature shall be copied to preferably A4 or A3 size or ANSI equivalent. Manufacturer's literature which is too large or which is not bindable should be referenced on the cover sheet and packed inside catalogue boxes, each of which shall be provided with an inventory attached to the lid.

Volume 3 – Operators' manual – a purpose written document for daily reference by the bridge operators

Volume 1 shall be provided as part of detail design documentation. The requirements for Volumes 2 and 3 shall be defined as part of the construction information and shall be provided by the appointed contractor.

All documentation shall be provided in both paper form (three copies) and digitally. The digital files shall be in the native file format along with a fully referenced and linked PDF copy.

## 6. PLANT ROOM

### 6.1 General layout

The hydraulic power pack (which includes the motor pump units, valves and tanks associated with the actuation of the cylinders) and electrical control and distribution cabinets will be located in the plant room in the south abutment. The plant room layout will be developed further during the design process and will consider ease of access for maintenance and inspection, along with ensuring that the equipment is safe and secure.

The hydraulic cylinders will be located in the main pier.

Key Plan drawing 3502-RAM-SB-XX-DR-CB-30001 in the Structural AIP shows the layout of the site.

### 6.2 Drainage and associated pumping requirements

The base of the plant room and cylinder pit will be inclined and a sump provided to enable any water that does enter these areas to be pumped out. The pump will permanently installed and will have a built in sensor to detect the water, hence it will start only if required.

Water that has collected in the cylinder pit shall be pumped into the sea.

The pump will not automatically start if low level oil warning is on and never within 20 minutes from a bridge operation. If oil is present in the plant room or cylinder pit, it will be manually pumped out of the pit.

### 6.3 Plant room environment: heating, lighting, humidity, ventilation

Heating, humidity and ventilation

The plant room will not be heated. The electrical cabinets will be equipped with anticondensation heaters. No further provision will be made to control humidity.

No ventilation within the plant room is proposed unless it is needed as highlighted as part of detailed design. The requirement for ventilation is based upon the maximum frequency of operation and the size of the hydraulic tank.

Lighting

The plant room and cylinder pit will be equipped with lighting, including provision of battery backed lighting.

#### 6.4 Mechanical and electrical equipment

- Electrical power and control cabinets (plant room)
- Multiple drive motors to drive the hydraulic pumps
- Pivot bearings
- Shock absorbers at the fully lowered positions
- Sensing:
  1. Bridge fully lowered (x2)
  2. Bridge fully raised (x2)
  3. Bridge positional monitoring (rotary encoder at pivot or inclinometer attached to the bridge)
  4. Pressure in cylinder bore (x2 per cylinder)
  5. Nose locking pin inserted (x2 per pin)
  6. Nose locking pin retracted (x2 per pin)
  7. Barriers fully opened (x1 per barrier)
  8. Barriers fully closed (x1 per barrier)
  9. HPU, high oil temperature (x1 warning and x1 fault)
  10. HPU, low oil level (x1 warning and x1 fault)
  11. HPU filter blocked (x1 per filter)
  12. HPU, motor running (x1 per motor)
  13. HPU, motor tripped (x1 per motor)
- Pipework and cables running from the plant room to the cylinder pit.
- Power sockets for portable tools in the following locations:
  - Control room
  - Plant room
  - Cylinder pit

#### 6.5 Security: intruder and fire alarm systems

The plant room and main pier machine room will be provided with fire detection and alarms.

Outline specification document will be provided at the detail design stage for fire detection and alarm, design and supply of both system provided by local contractor.

These will be connected into the control room. A fire alarm activation will register in the control room and the relevant authorities will be notified via automated message if suitable system is available. To allow the operator to operate the bridge during fire alarm maintenance routine, the operator will be able to override the fire alarm signal.

An intruder alarm system will not be provided.

Rev P02

#### 6.6 Proposed fire-fighting measures

Fire extinguishers suitable for the likely fires (electrical / oil) and in accordance with NFPA standards.

No automated fire-fighting system is proposed.

Rev P02

## 7. DESCRIPTION OF INSPECTION AND MAINTENANCE ARRANGEMENTS

#### 7.1 Proposals for inspection and maintenance of bridge structure

Proposals for inspection and maintenance of the movable bridge structure are given in the Structural AIP.

#### 7.2 Proposals for inspection and maintenance of M&E installation

In addition to the maintenance requirements for the structure, the following will apply for the mechanical, hydraulic and electrical equipment:

- All accessible equipment is to be visually inspected on a weekly basis.

- Lubrication of pivot – annually – to be reviewed after a period of bridge use.
- Detailed inspection of equipment – bi-annually, covers removed, close access to each component is achievable over land, change fluid filters, test all methods of operations.
- Long term – change hydraulic fluid, electrical tests, etc., replace cylinder seal, cylinder refurbishment, bearing replacement.

### 7.3 Proposed documentation

Operation and maintenance requirements, including methods of moving the bridge using back-up systems, will be detailed in the operation and maintenance (O&M) manual.

### 7.4 Proposals for plant monitoring, data collection and management

As a minimum, the following sensing shall be provided:

- Bridge fully open (x2) (located at either the nose or pivot)
- Bridge fully closed (x2) (located at the nose to ensure correct alignment)
- Bridge positional monitoring (rotary encoder on motor or attached to bridge at pivot)
- Barrier lowered (per barrier)
- Barrier raised (per barrier)

The following shall be recorded as a minimum:

- All alarms, faults and warnings
- Operators' activation of the system
- Bridge operating duration

## 8. CHECK

### 8.1 M&E installation to be Category 3

### 8.2 Name of the proposed independent Checker

To be appointed by Government of Bermuda.

## 9. DRAWINGS AND DOCUMENTS

### 9.1 List of drawings and documents (including numbers) accompanying the submission

Drawing list:

- 3502-RAM-SB-XX-DR-M-3001 General arrangement of mechanical assemblies
- 3502-RAM-SB-XX-DR-M-3002 Pivot assembly
- 3502-RAM-SB-XX-DR-M-3003 Abutment cylinder mount assembly
- 3502-RAM-SB-XX-DR-M-3004 Upper cylinder mount assembly
- 3502-RAM-SB-XX-DR-M-3005 Locking nose pin assembly
- 3502-RAM-SB-XX-DR-M-3006 Barrier assembly

### 9.2 List of documents relating to inspection, maintenance and safe operation

Operation and Maintenance (O&M) manual to be issued on project completion.

Risk assessment included in the Structural AIP.

Updated risk assessment to be issued on project completion.



## 10. THE ABOVE IS SUBMITTED FOR ACCEPTANCE

Signed	<u>Bottamedi Consuelo</u>
Name	Consuelo Bottamedi
Engineering Qualifications	MEng CEng MIMechE
Position Held	Designer
Name of Organisation	Eadon Consulting Ltd
Date	10/04/2019.....

## 11. THE ABOVE IS REJECTED/AGREED SUBJECT TO THE AMENDMENTS AND CONDITIONS SHOWN BELOW

Signed	<u>Atila Fustos</u>
Name	Atila Fustos
Position Held	<u>Principal Engineer</u>
Engineering Qualifications	<u>MICE, CEng.</u>
TAA	Bermuda Government
Date	<u>11 April 2019.</u>

## **APPENDIX 1**

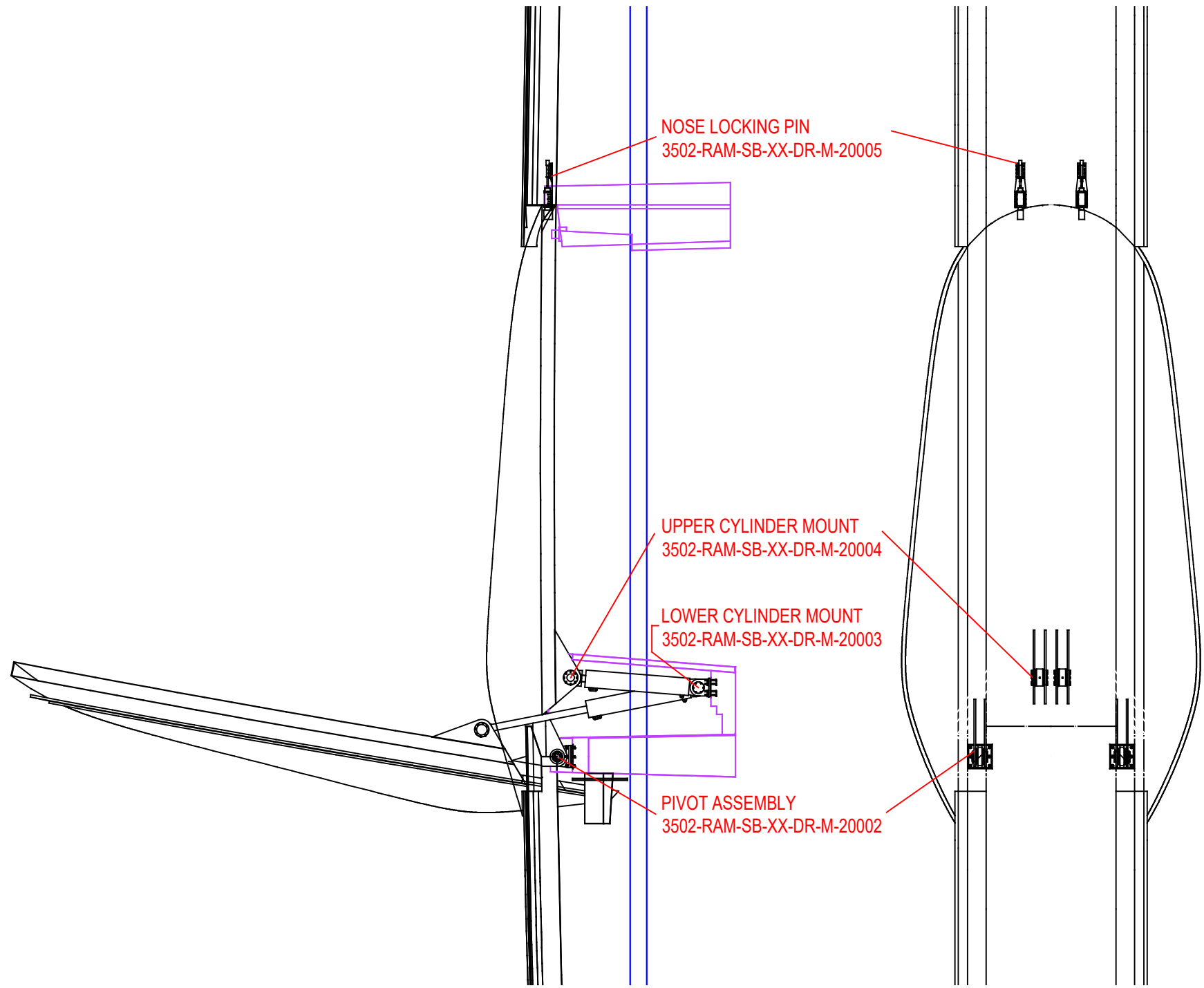
### **TECHNICAL APPROVAL SCHEDULE (TAS)**

## **Technical Approval Schedule (TAS)**

Please refer to Structural AIP.

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- Notes
- DO NOT SCALE FROM THIS DRAWING.
  - ALL DIMENSIONS ARE MILLIMETRES U.N.O.
  - ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM U.N.O.
  - THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.



REV	DESCRIPTION	DATE	BY	CHKD
001	PHASE II	04/05/2015	MNT	MNT

PRELIMINARY



REPLACEMENT OF SWING BRIDGE & LONGBIRD BRIDGE, BERMUDA



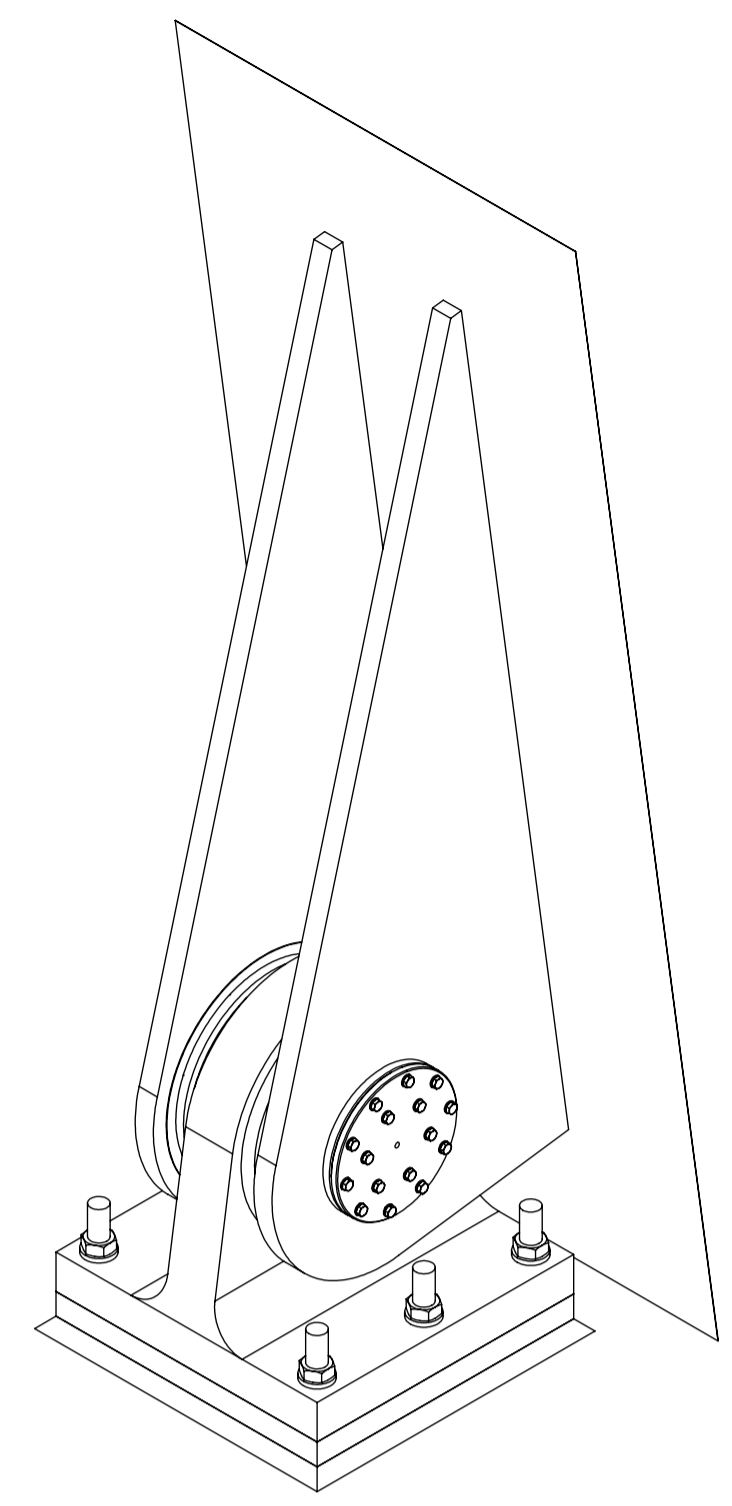
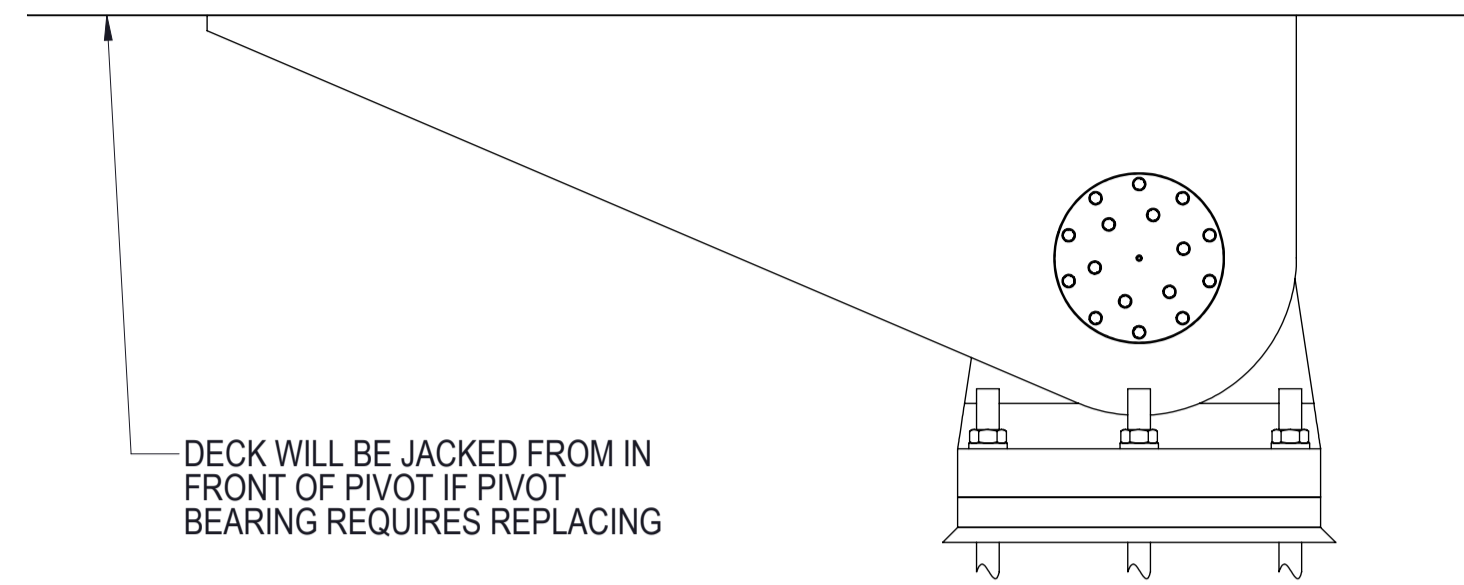
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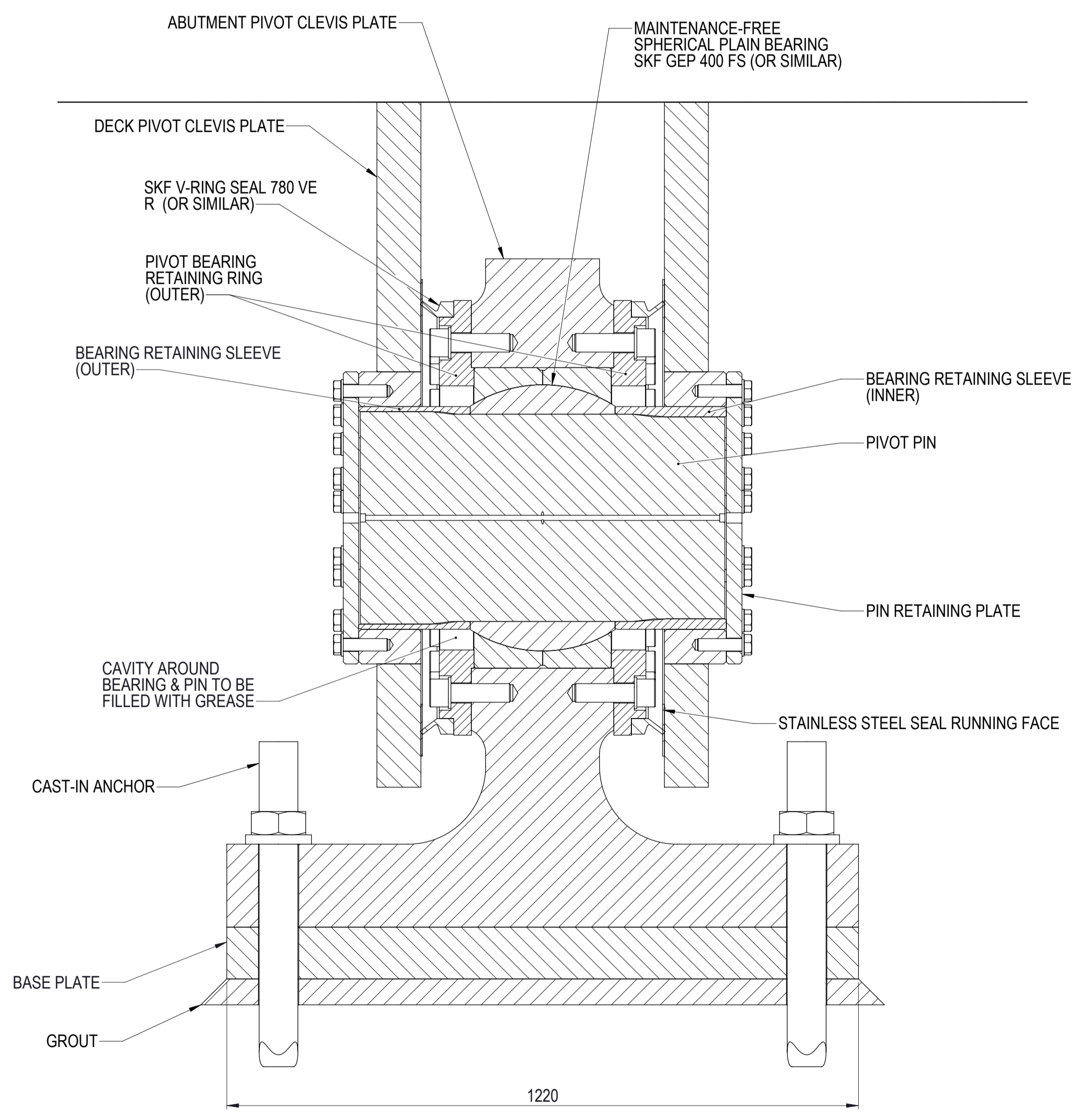
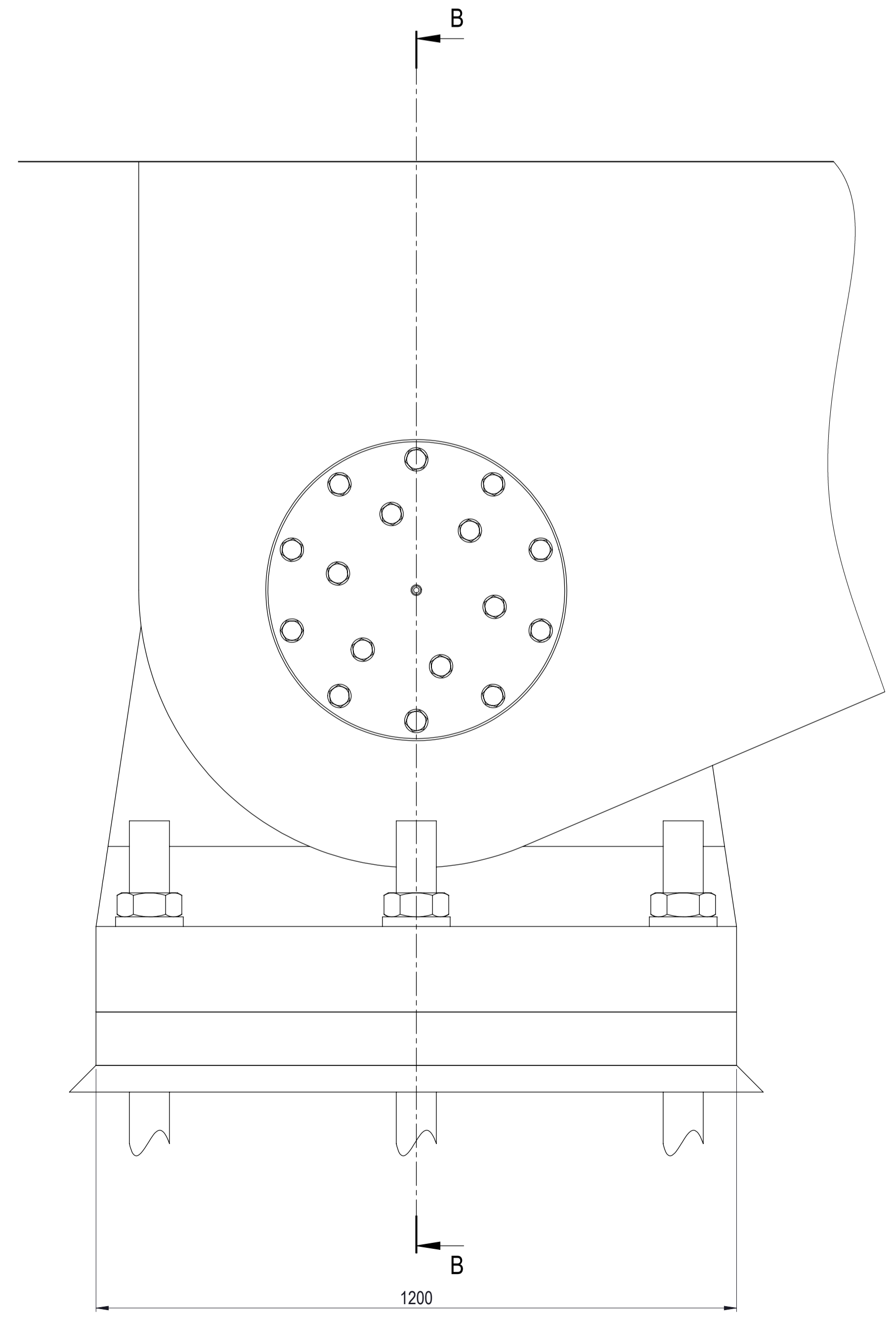
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SECTION B-B

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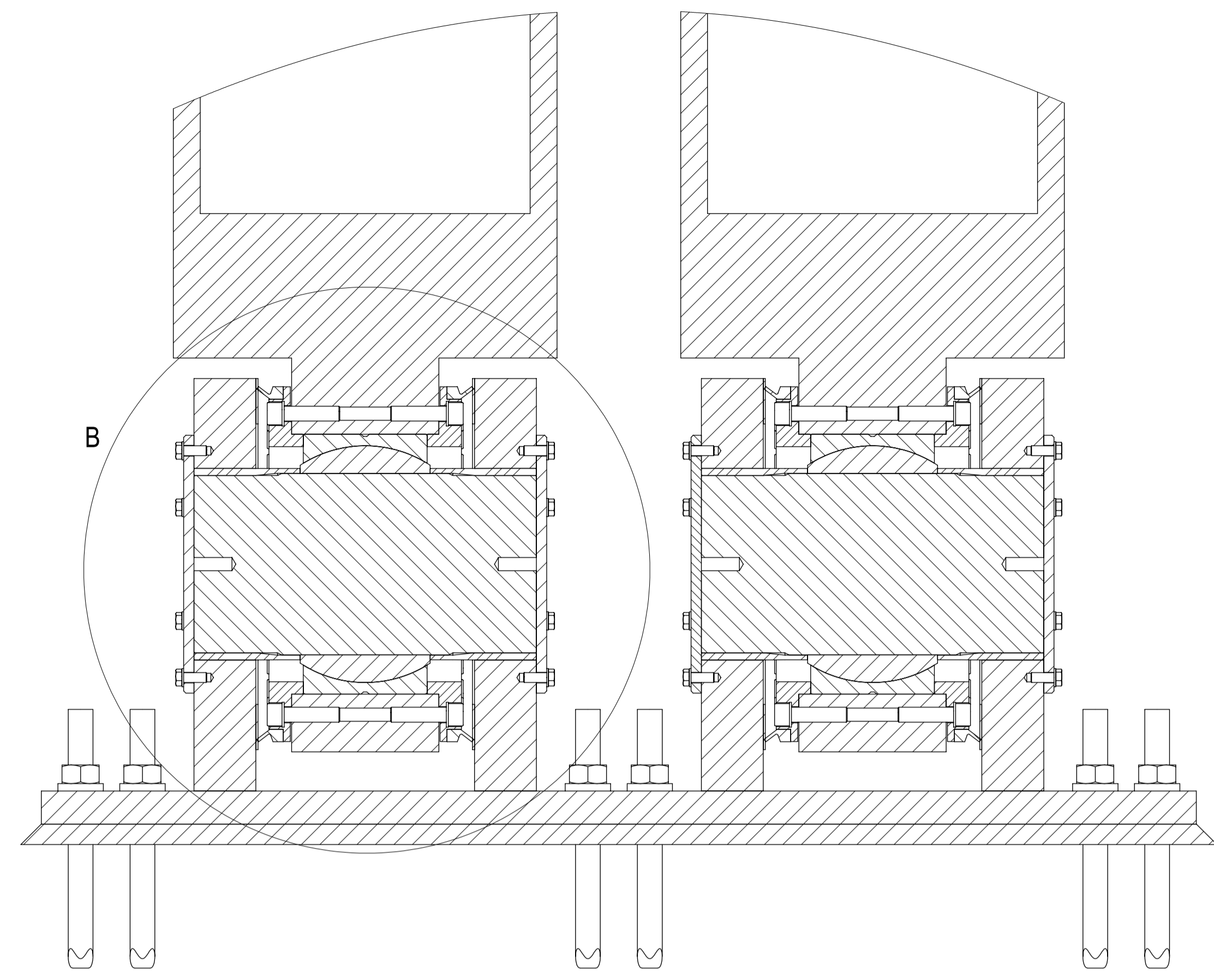
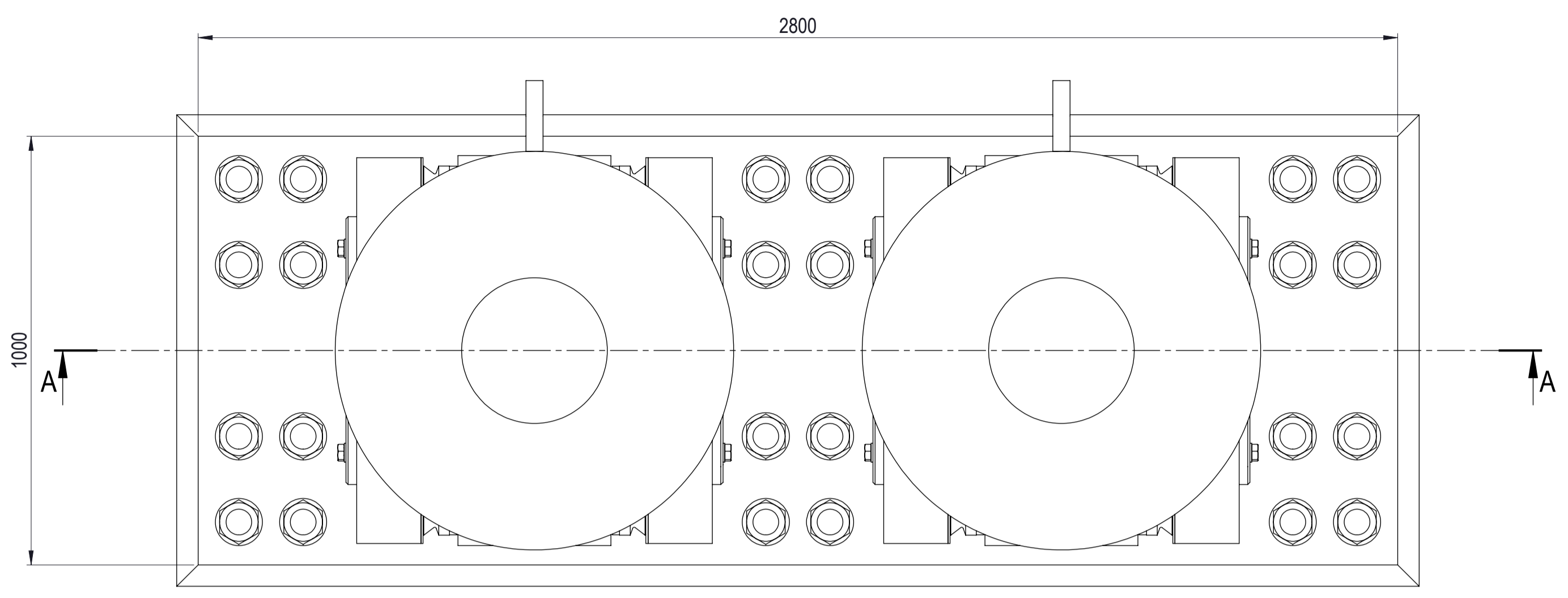
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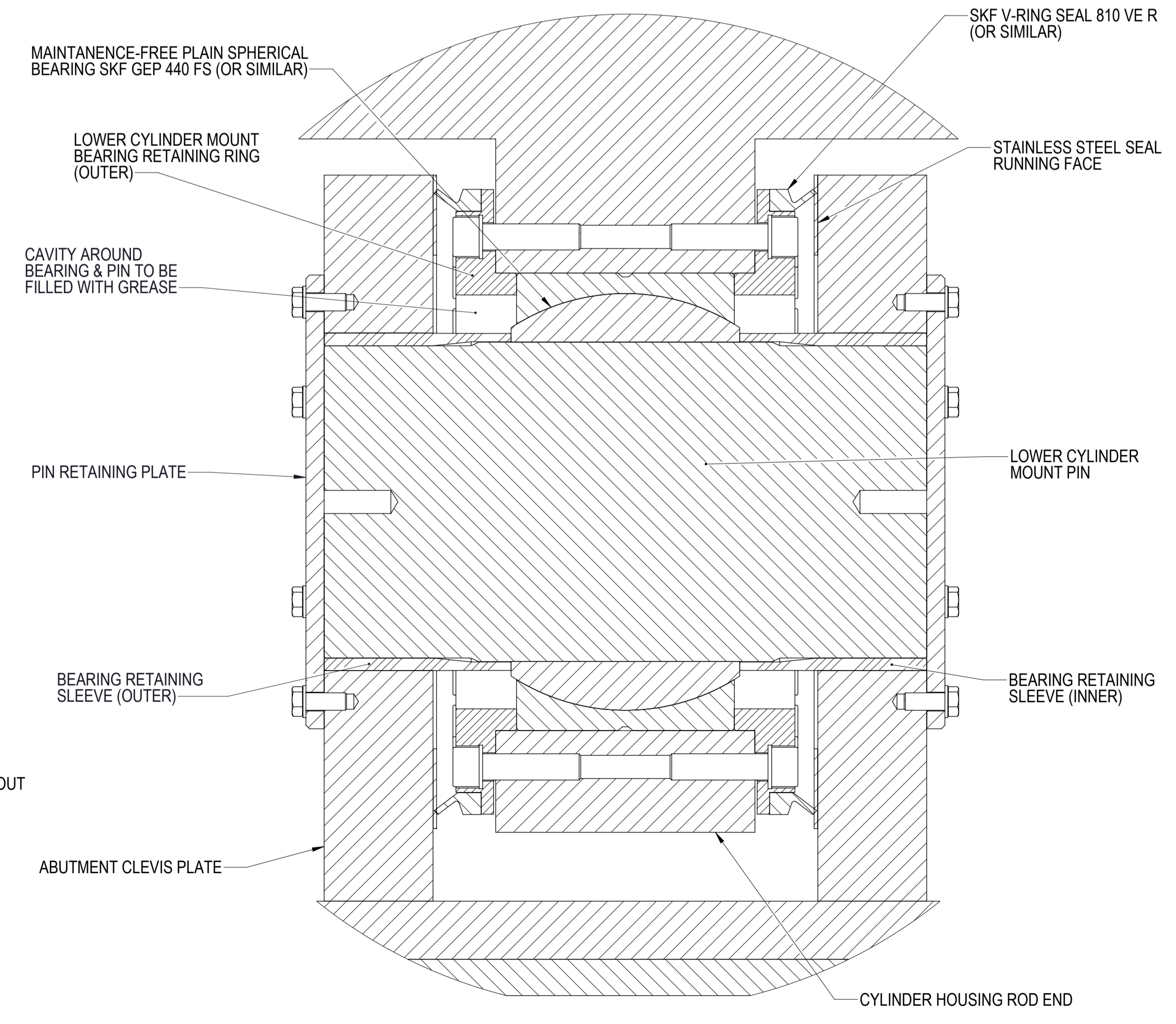
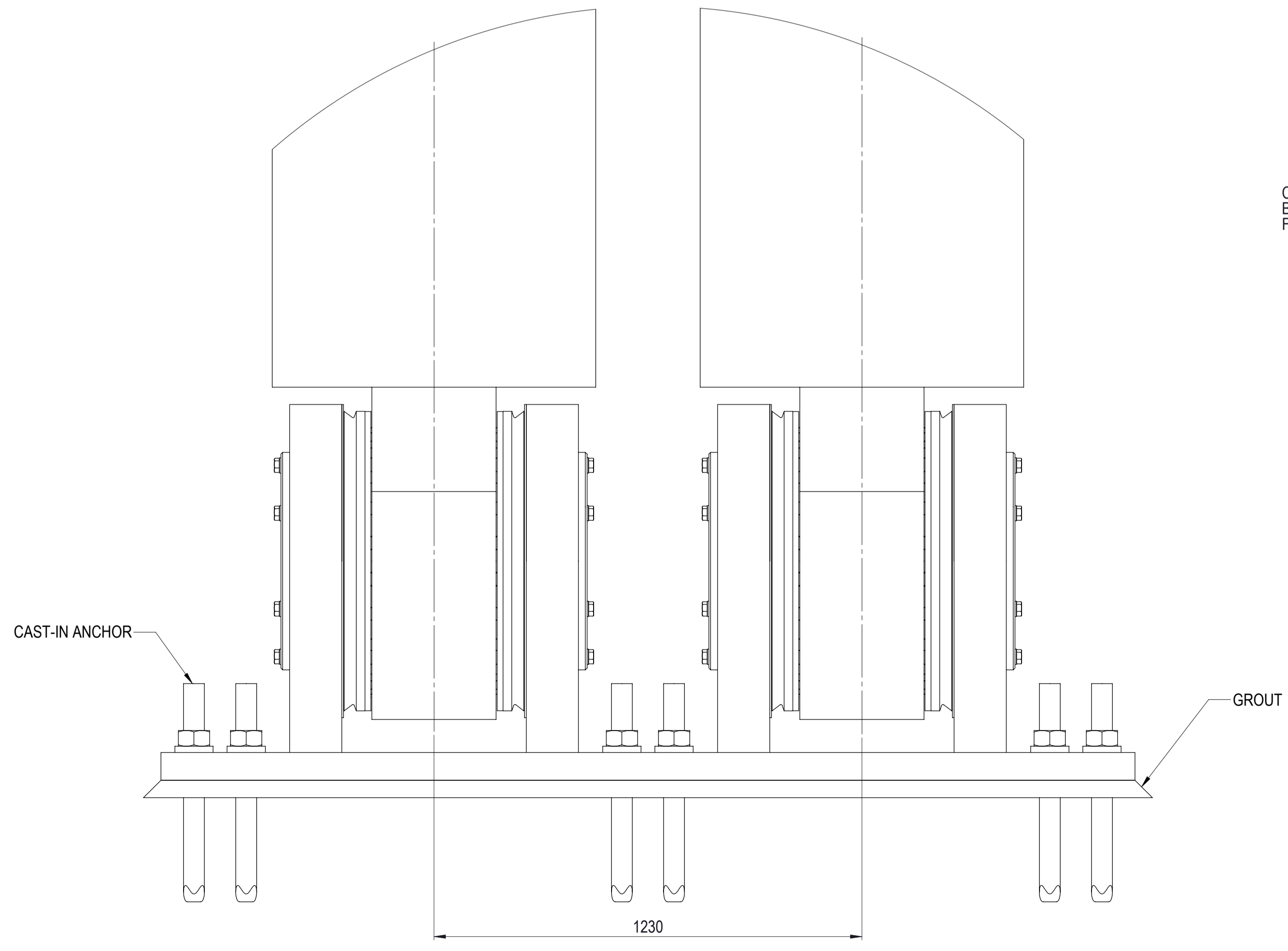
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SECTION A-A



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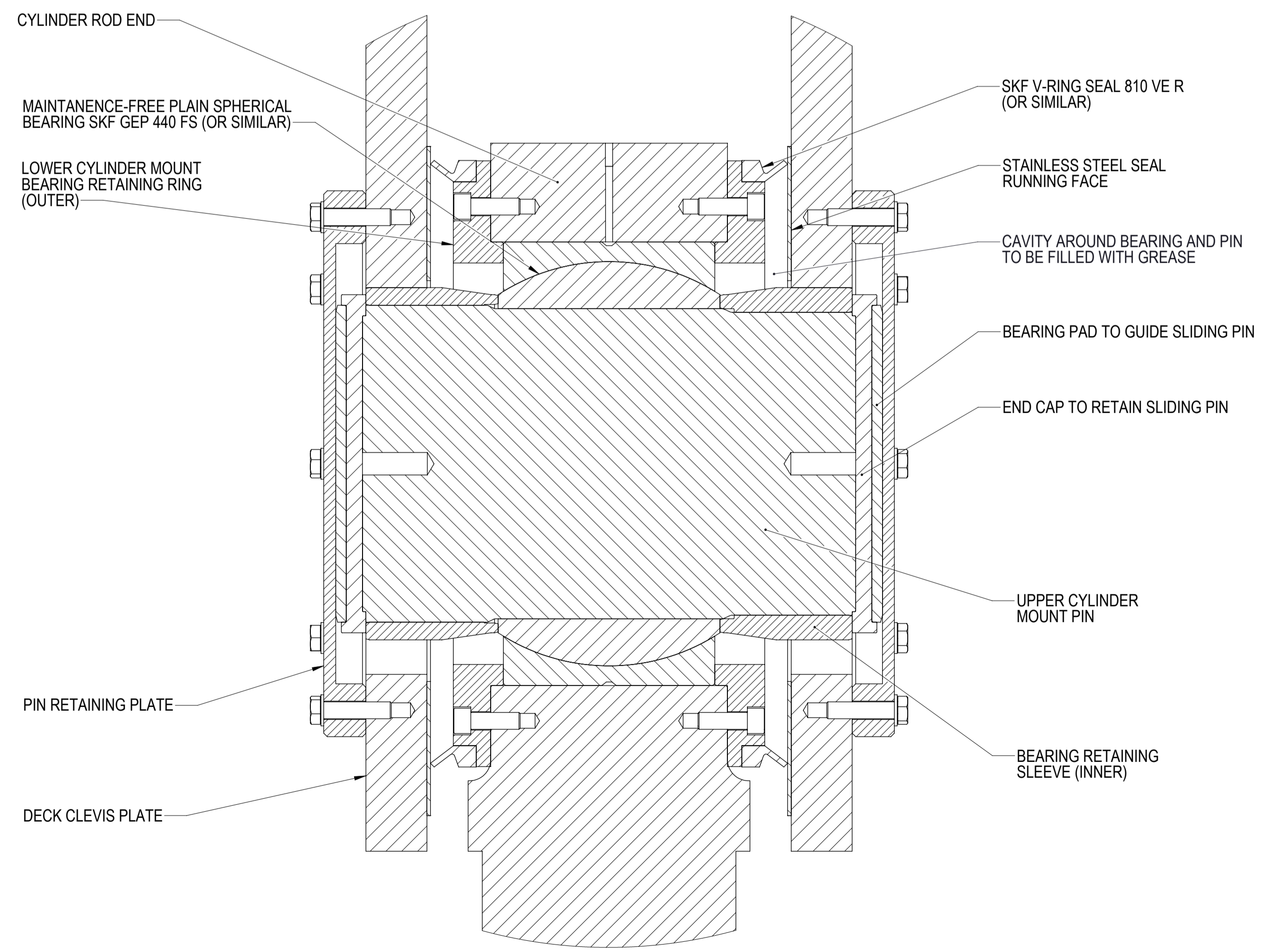
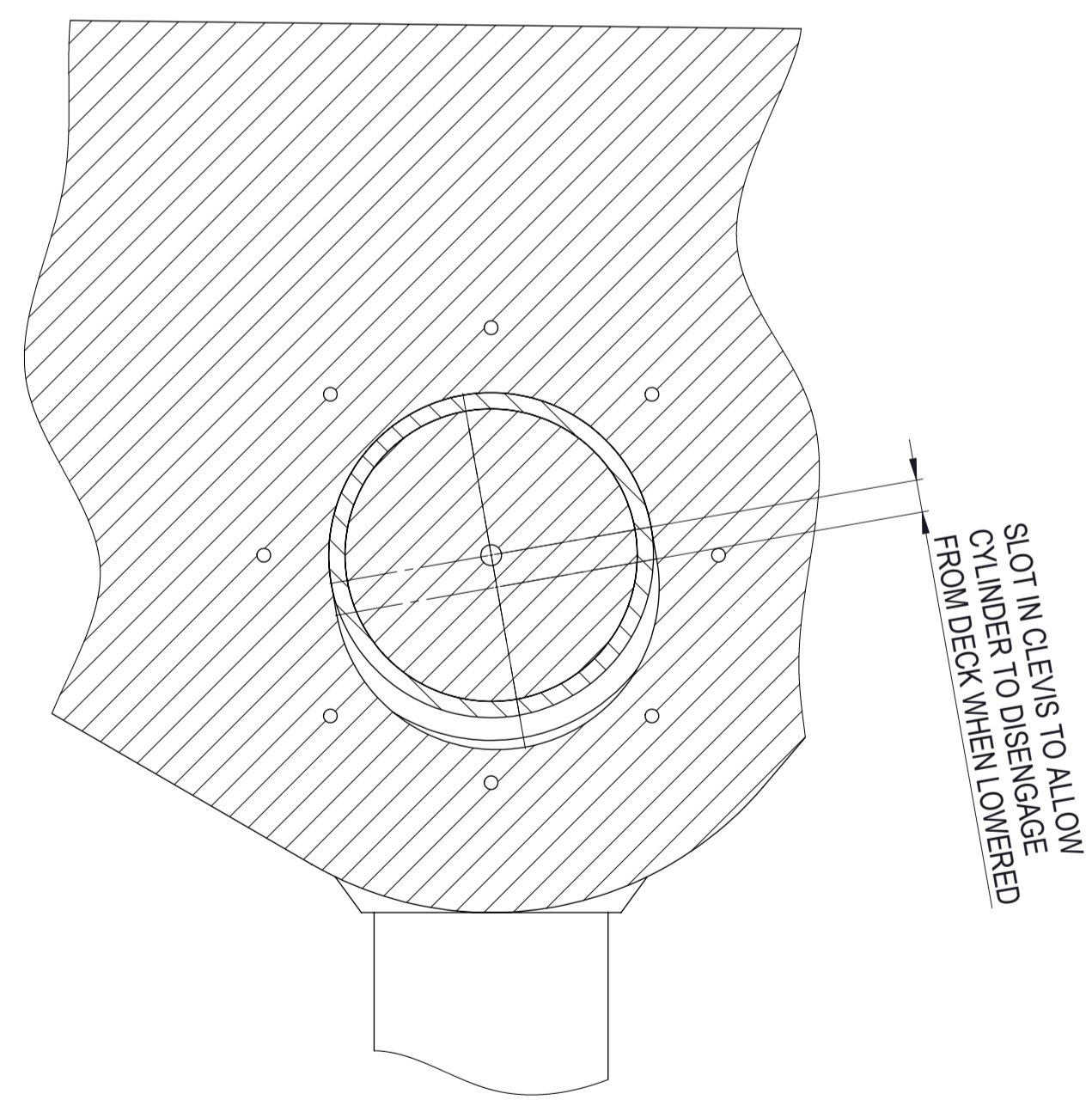
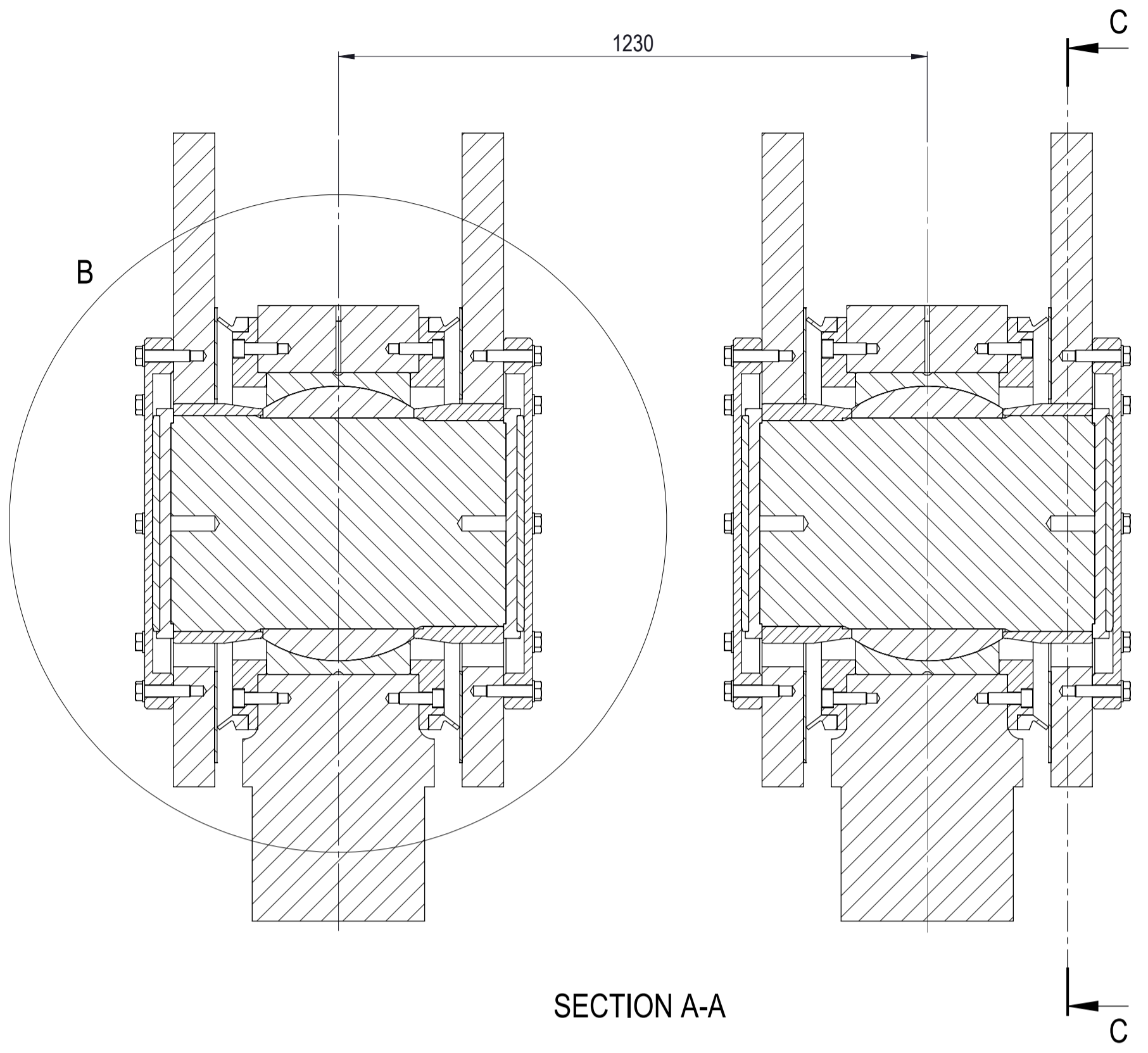
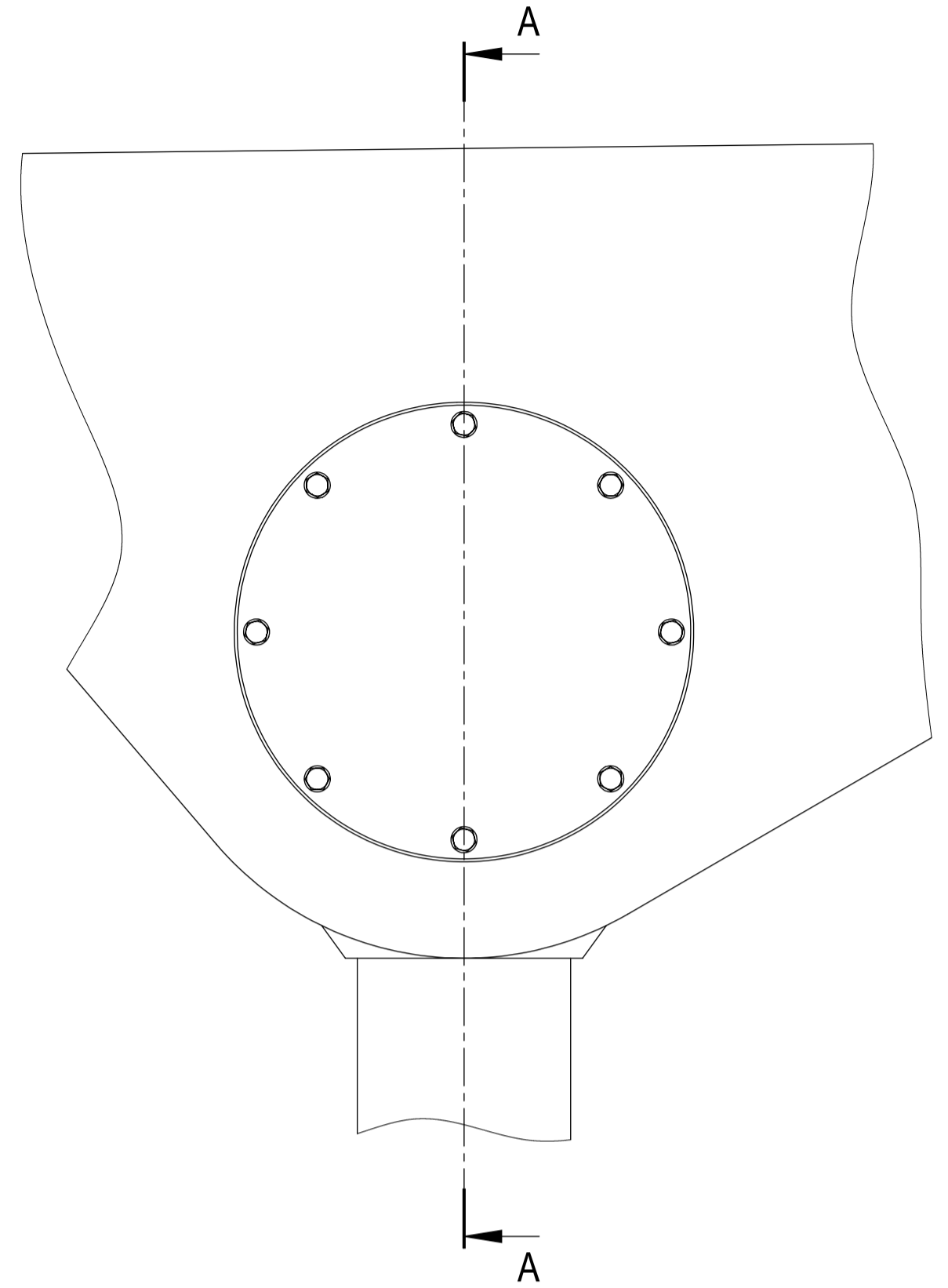


REPLACEMENT OF SWING BRIDGE & LONGBIRD BRIDGE, BERMUDA



SWING BRIDGE REPLACEMENT APPROVAL IN PRINCIPAL ABUTMENT CYLINDER MOUNT ASSEMBLY

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DETAIL B  
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SECTION C-C

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REPLACEMENT OF SWING BRIDGE & LONGBIRD BRIDGE, BERMUDA

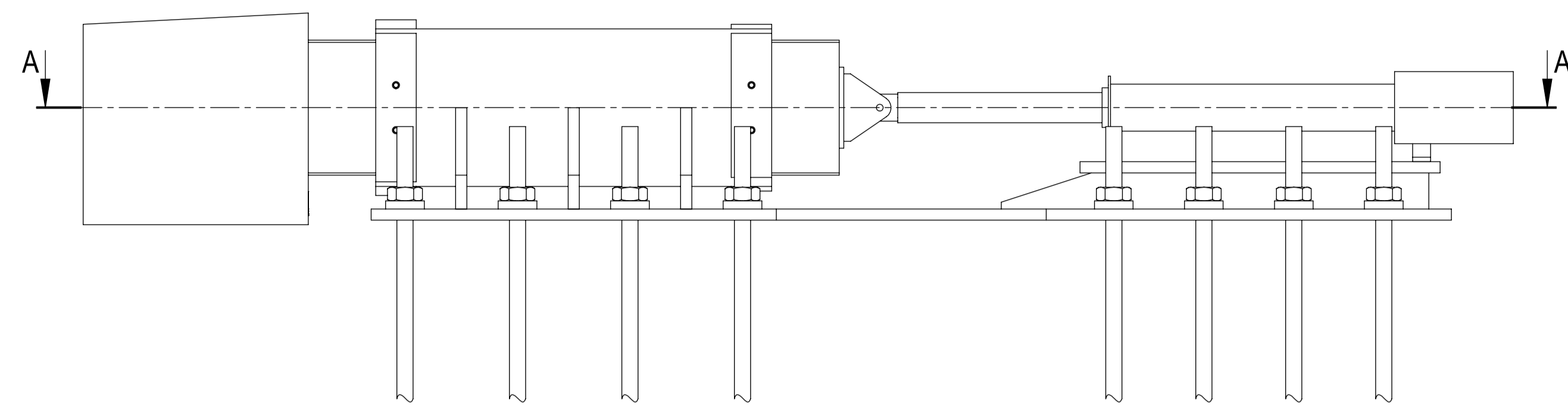


SWING BRIDGE REPLACEMENT APPROVAL IN PRINCIPAL UPPER CYLINDER MOUNT ASSEMBLY

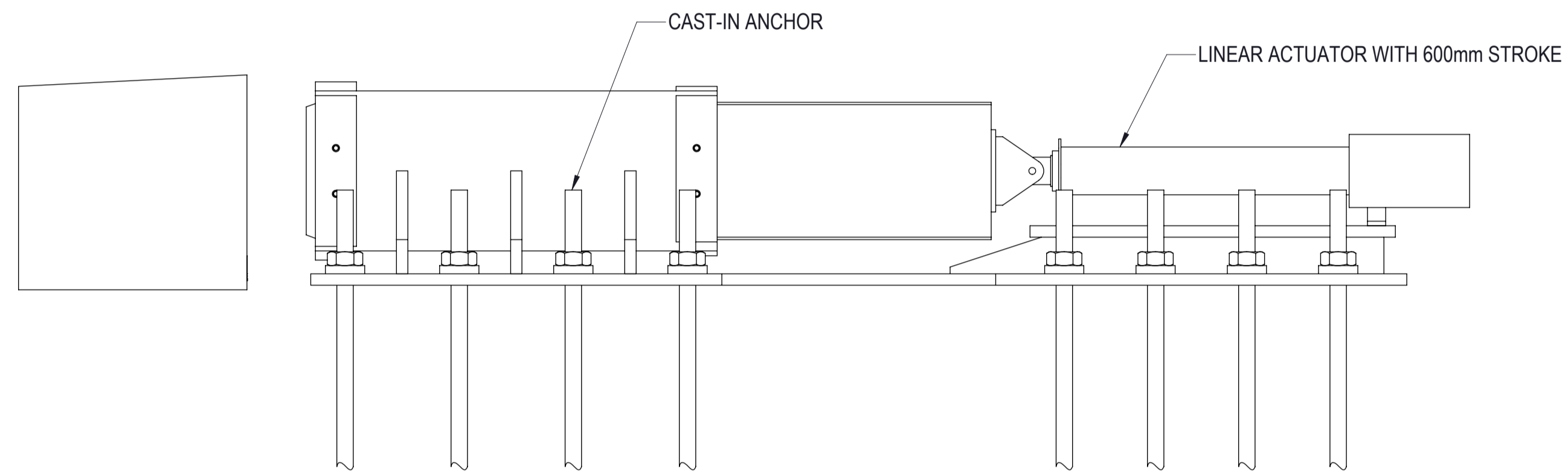
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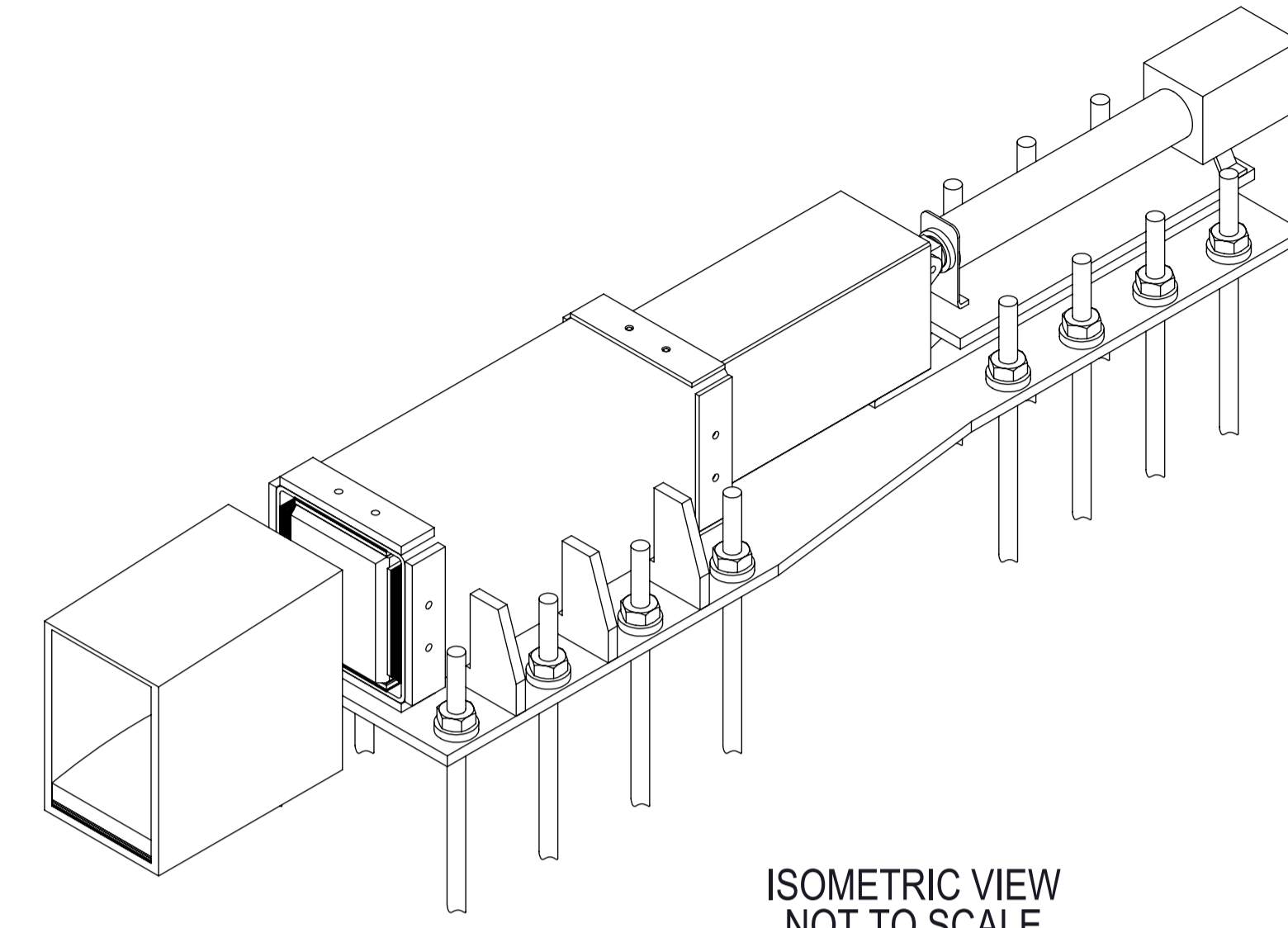
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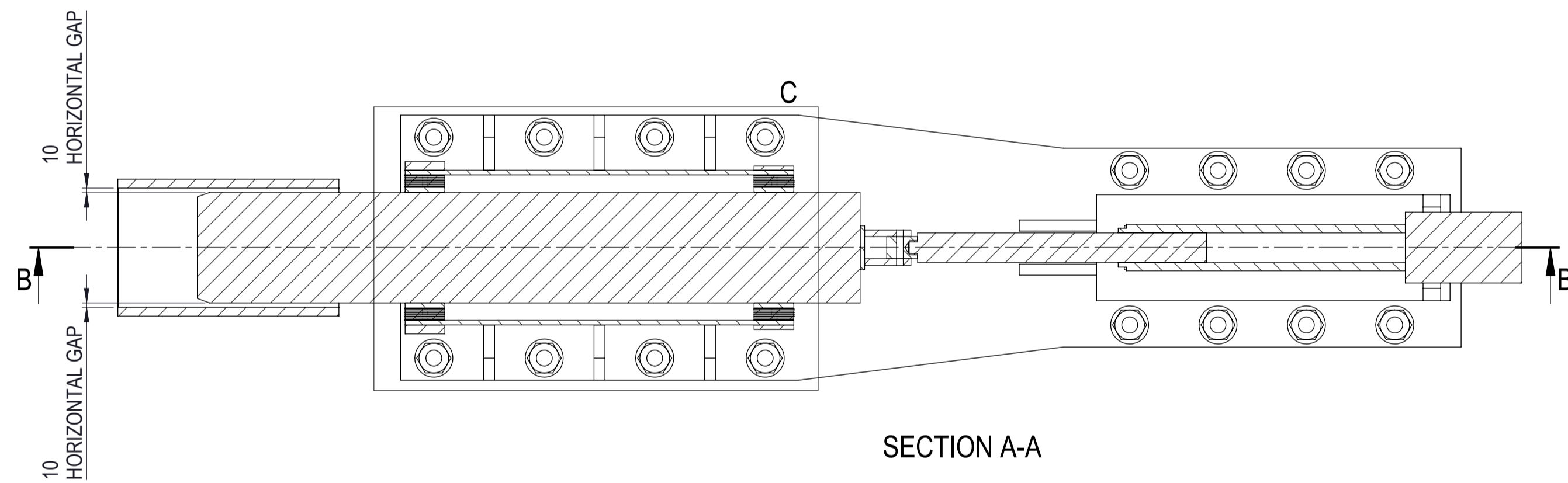
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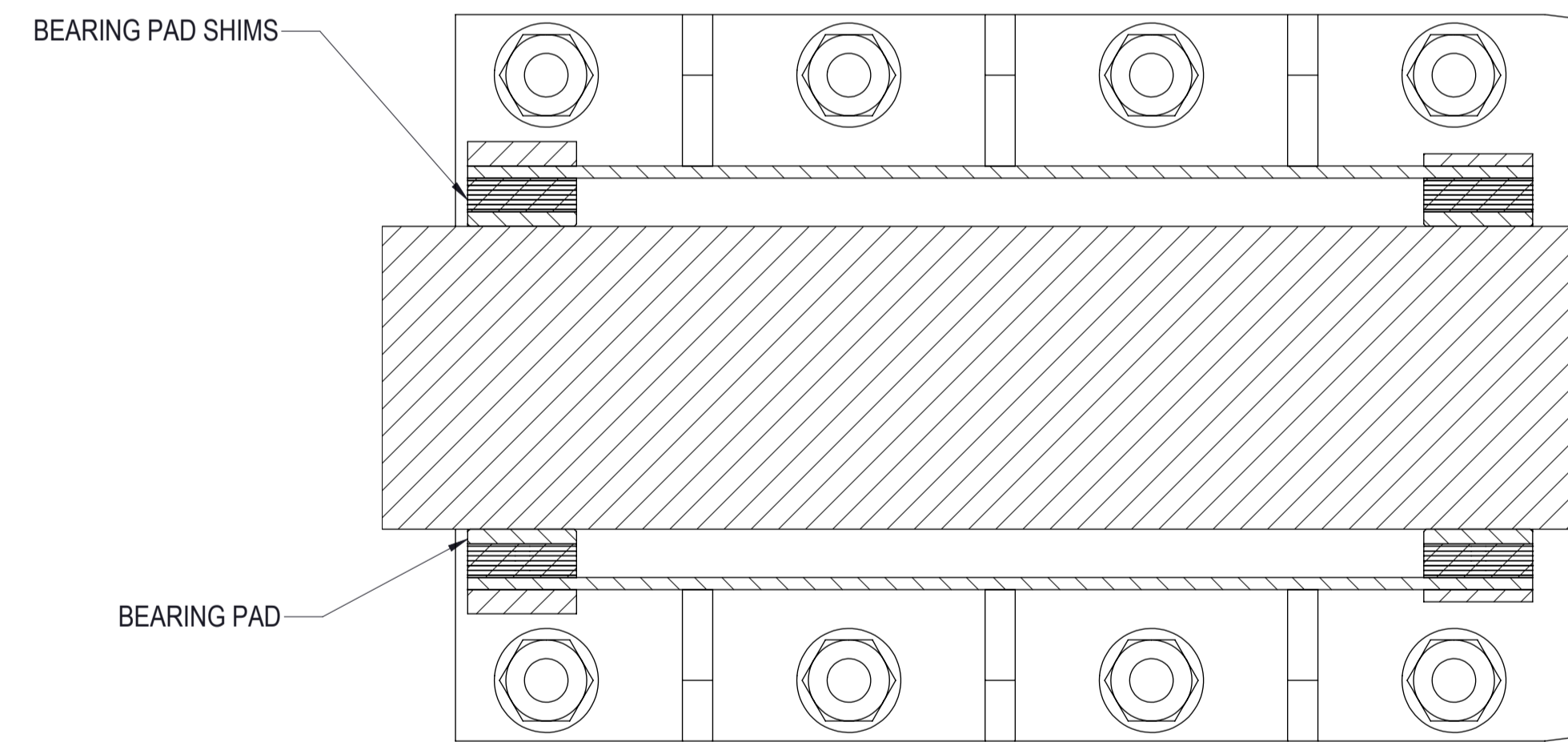
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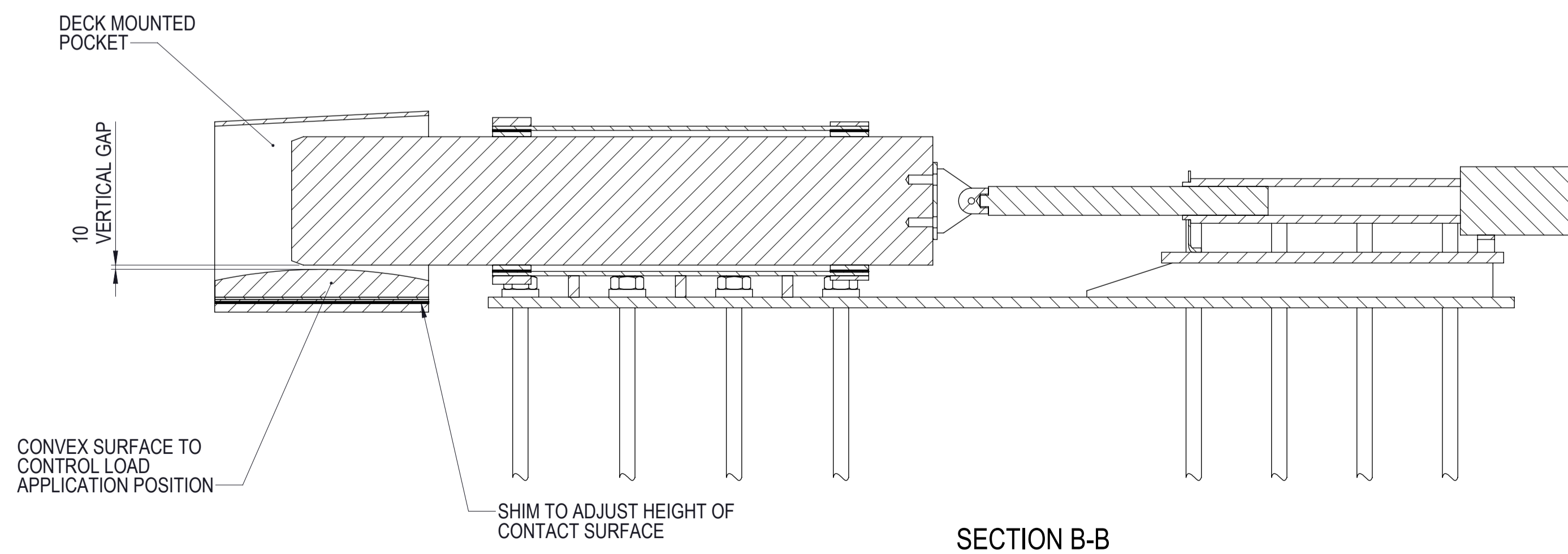
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SECTION A-A



DETAIL C  
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SECTION B-B

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REPLACEMENT OF  
SWING BRIDGE & LONGBIRD  
BRIDGE, BERMUDA



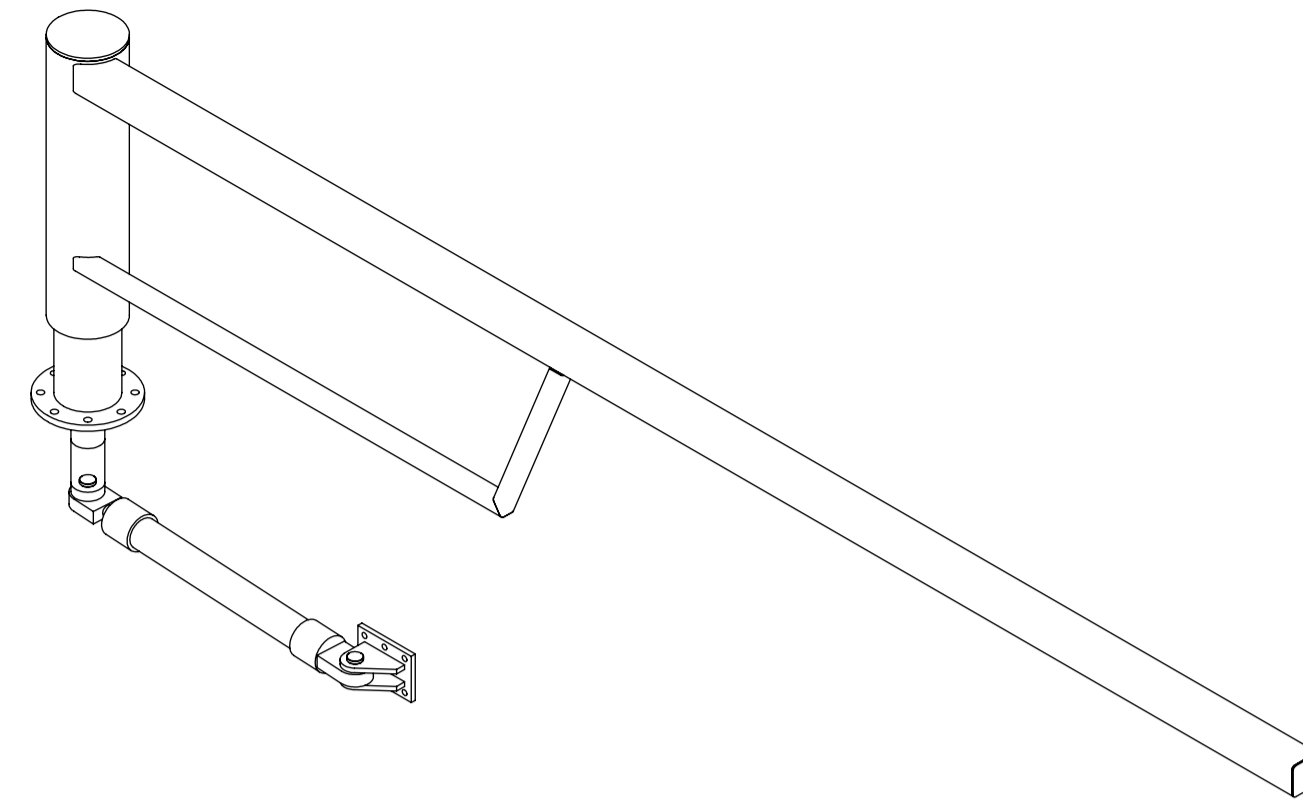
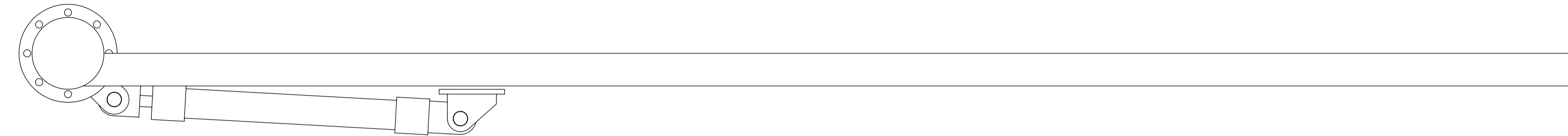
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LOCKING NOSEPIN  
ASSEMBLY

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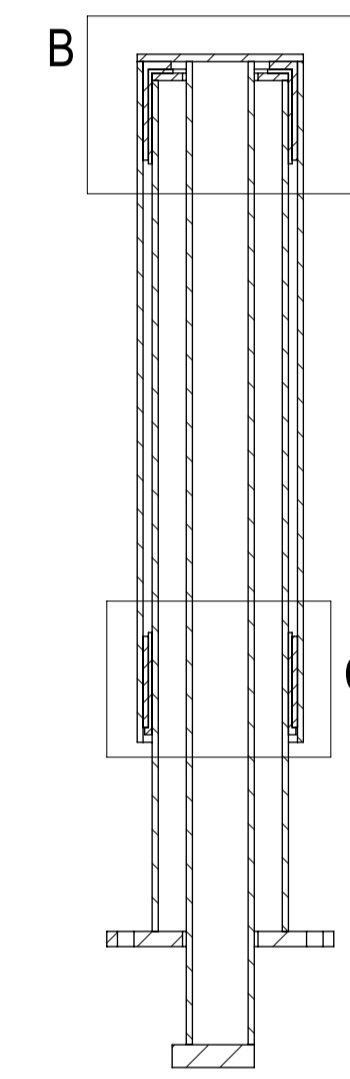
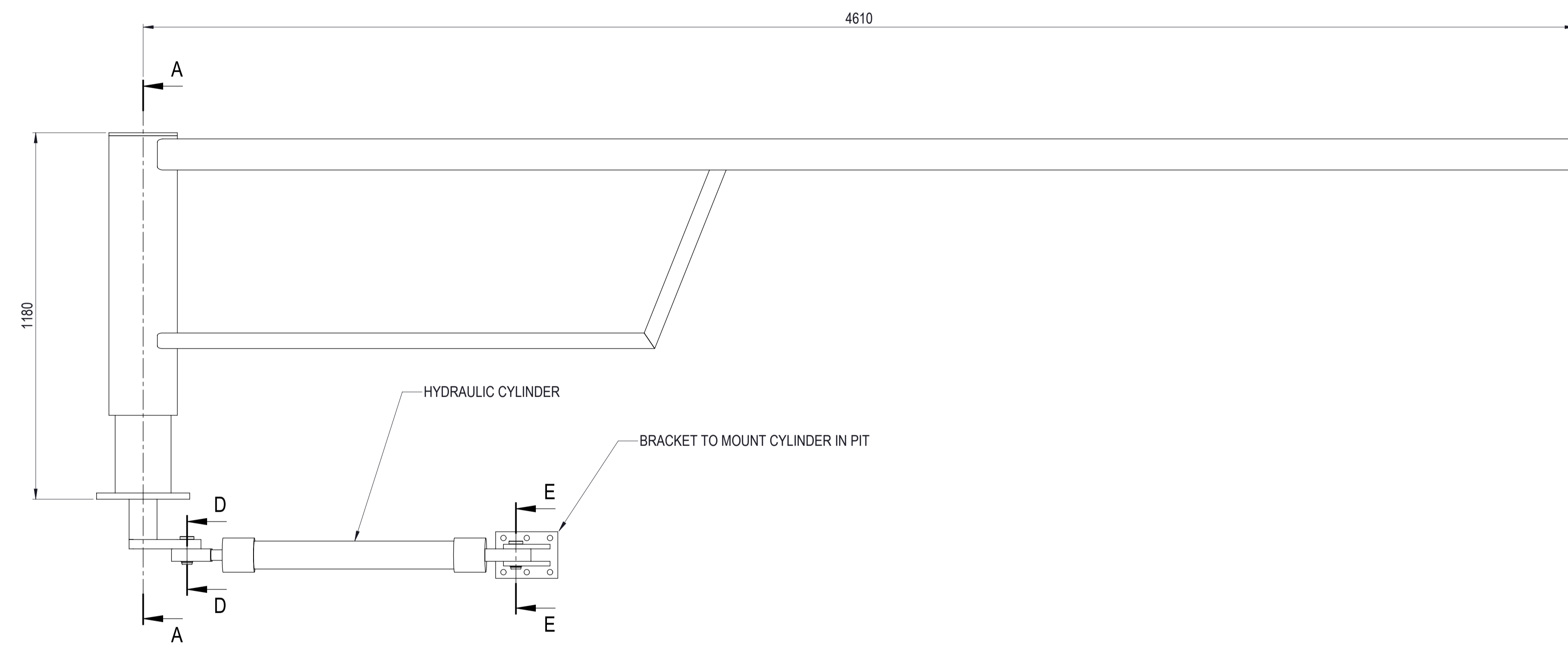


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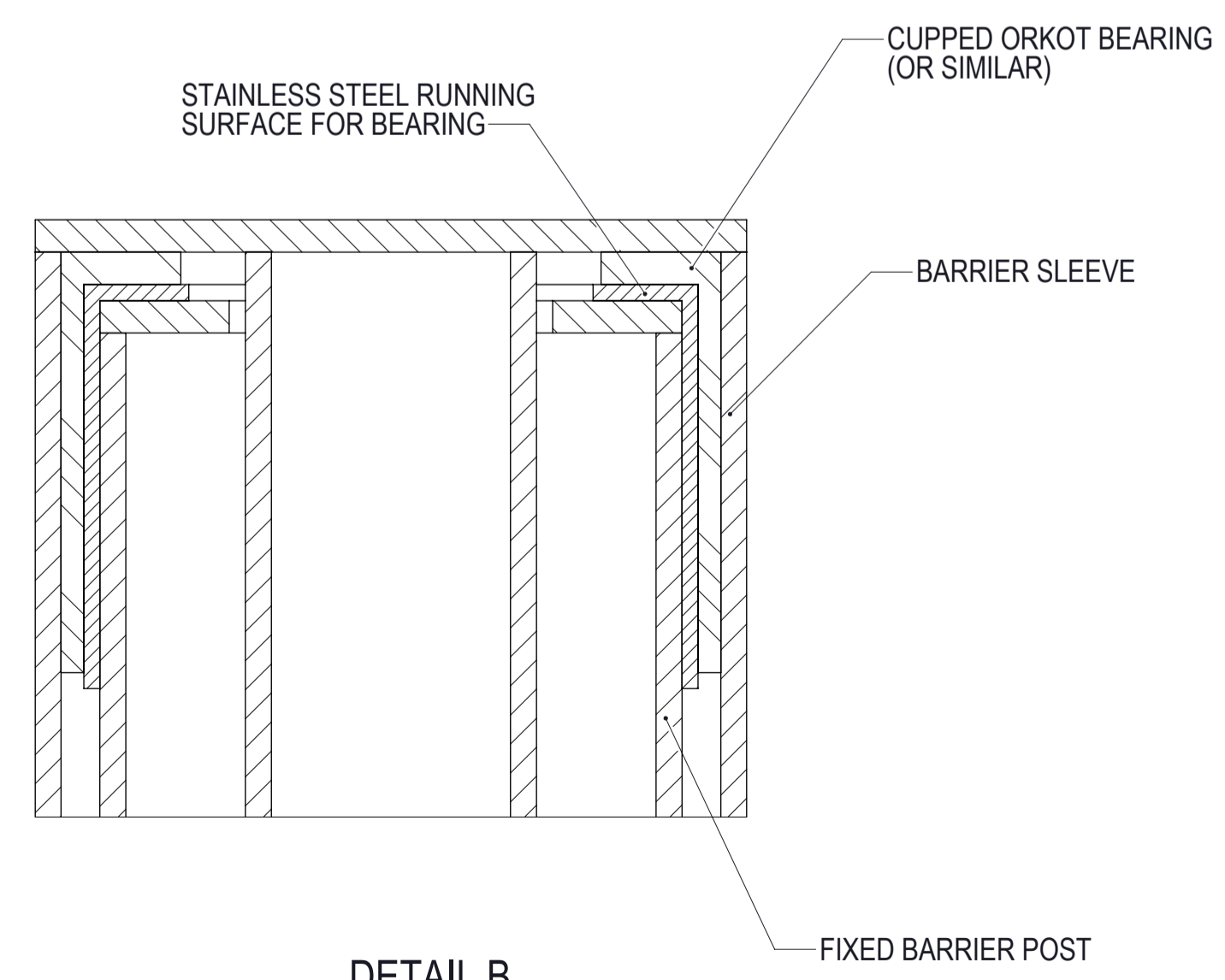
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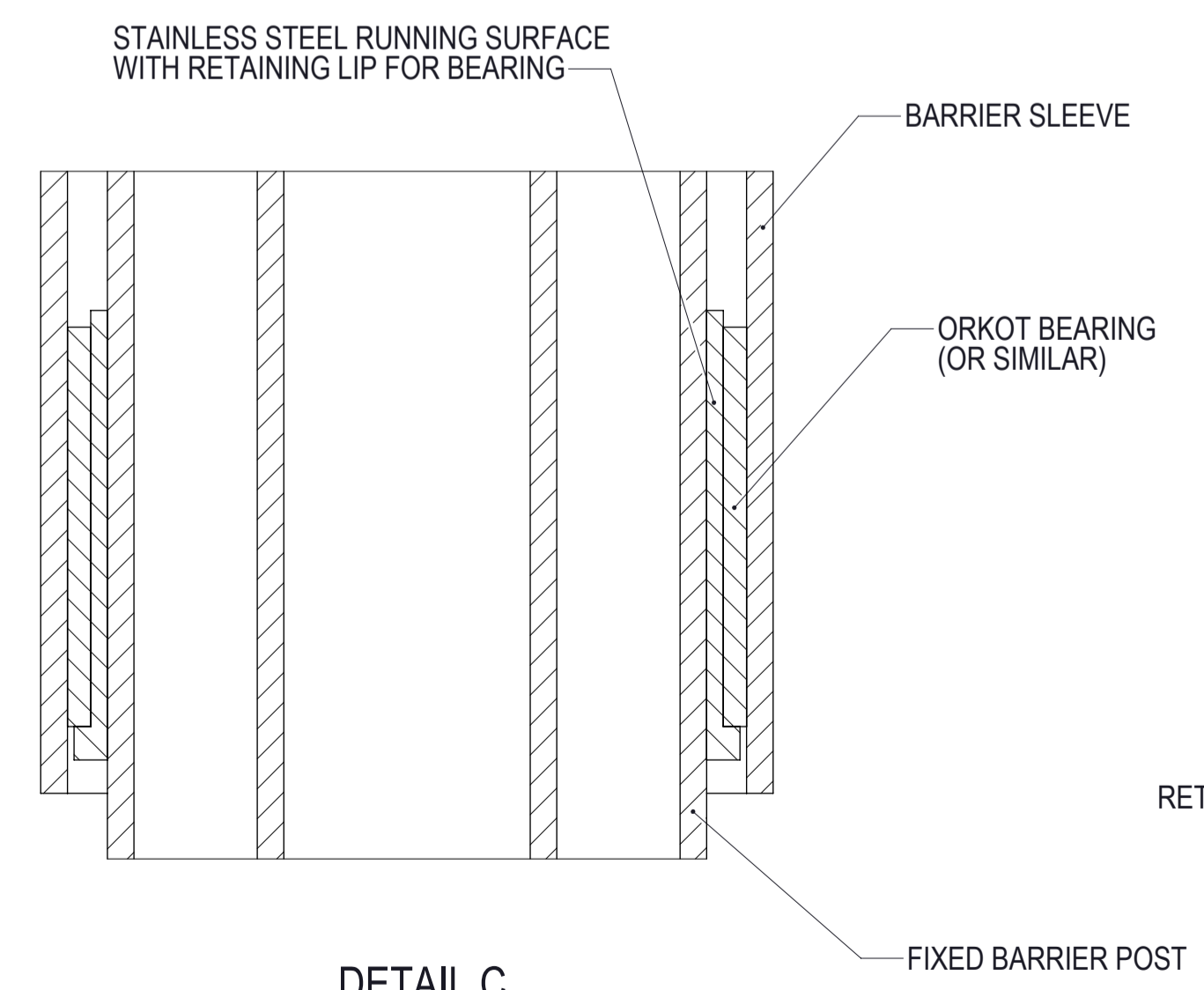
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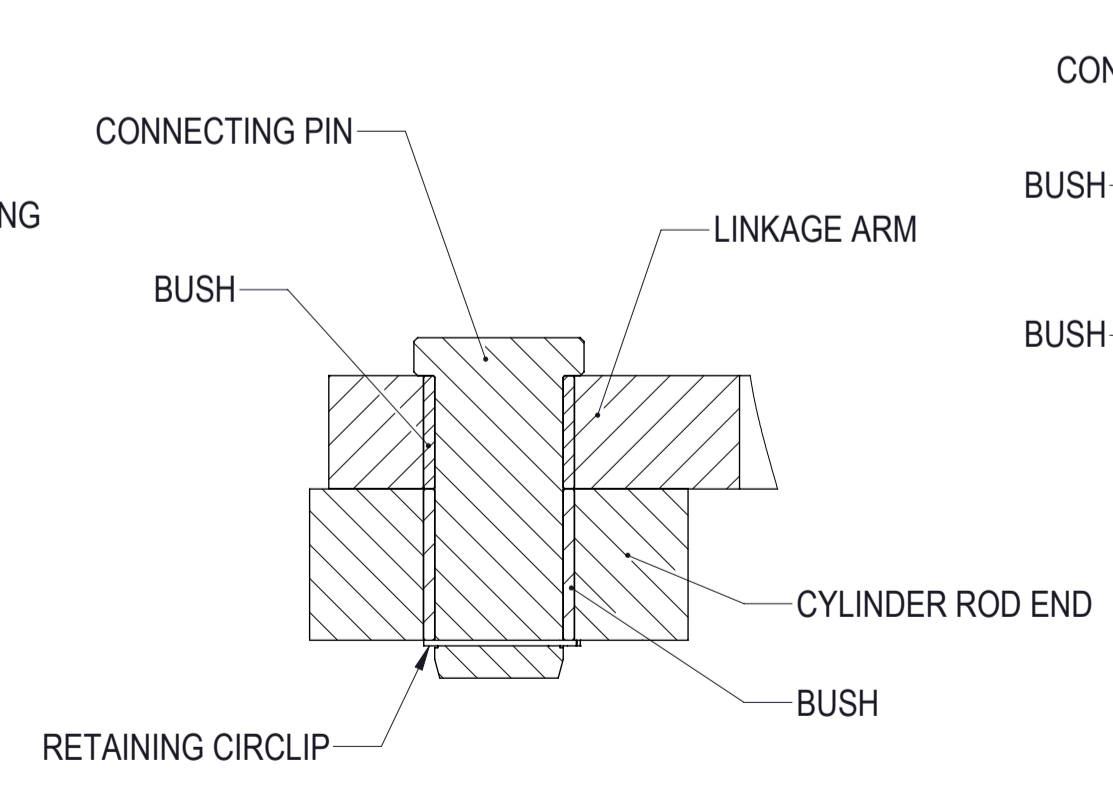
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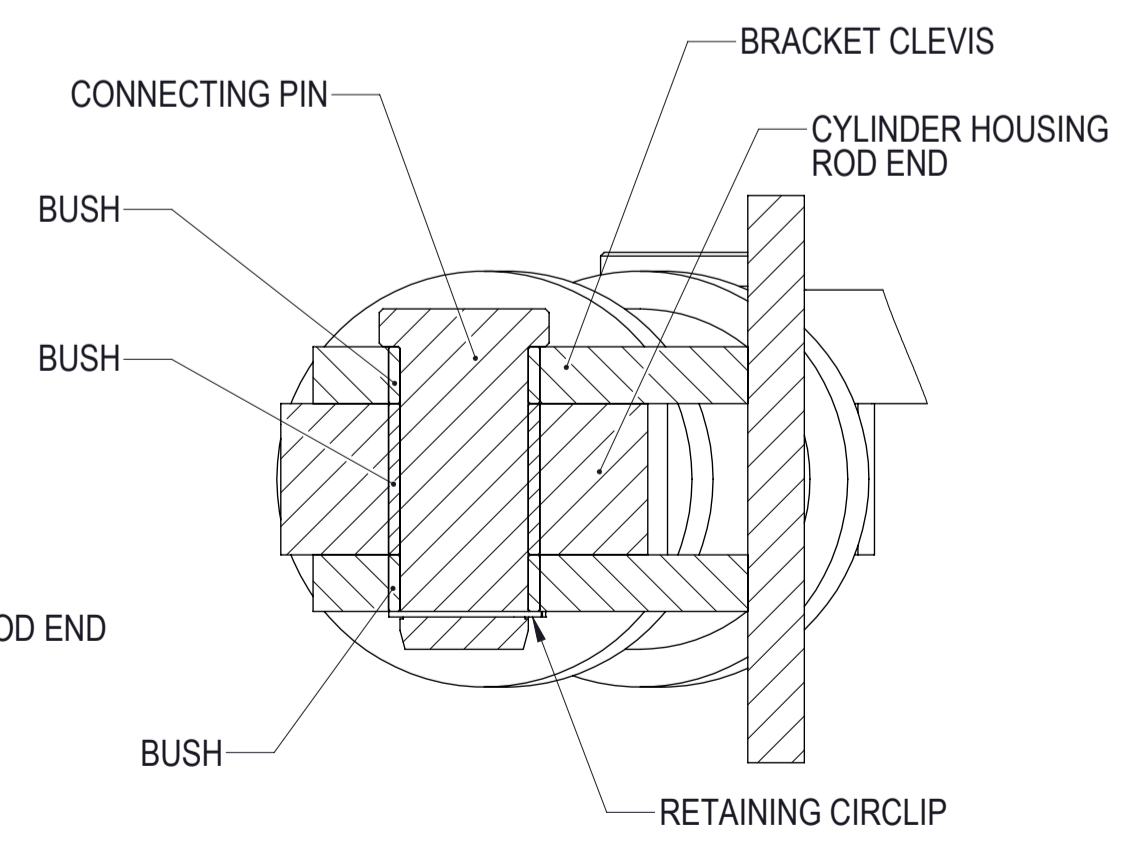
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DETAIL C  
SCALE 1 : 2



SECTION D-D  
SCALE 1 : 2



SECTION E-E  
SCALE 1 : 2

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Knight Architects



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BARRIER ASSEMBLY

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