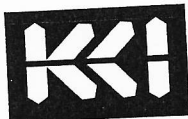




Section 3 Structural Inspection

Contents

1	Inspection for Fatigue Crack Growth	2
1.1	Background.....	2
1.2	Inspection Methods	3
1.2.1	Visual Inspection (VT)	3
1.2.2	Magnetic Particle Inspection (MT).....	3
1.2.3	Ultrasonic Inspection (UT)	4
2	Inspection of Bolted Joints	4
2.1	Visual Inspection	4
2.2	Bolt Torque Tightening	4
3	Inspection for Corrosion.....	5
3.1	External Corrosion of Steel Structures	5
3.2	Internal Corrosion of Box Type Beams	5
3.3	Acceptable Corrosion	5
3.4	Re-Painting of Surface Coatings.....	5
4	Frequency of Inspection	6
5	Reporting and Repairs	7
5.1	Reporting Procedure.....	7
5.2	Repair Procedure.....	7
6	Structural Inspection Plan.....	8



6.1	Upper Structures	10
6.2	Portal	24
6.3	Trolley & Operator's Cab	35
6.4	Bogies	43
6.5	Head Block.....	49

1 Inspection for Fatigue Crack Growth

1.1 Background

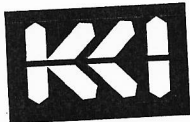
Welded steel structures always contain small un-detectable cracks, usually at welded joints. When these joints are subject to fluctuating stresses beyond a very small value, the cracks grow. This is called fatigue crack growth.

The allowable stress levels used in the design of the structure, take this phenomenon into account. The allowable stress levels are determined by analyzing laboratory tests. Typical details are subjected to cycles of stress fluctuation. The allowable stress level is determined by applying a factor of safety to the lower limit of the test data scatter band. In a few laboratory tests, failure occurs at a stress level below the allowable.

There are thousands of welded details in the crane structure, which are subjected to repeated stress fluctuation. It is probable that fatigue crack growth will take place in some details, before the end of full service life. This is a consequence of the statistical nature of the phenomenon.

There are no recognized crane specifications used in the world today, that have stresses at such a low level that fatigue crack growth will not be expected to occur on a random basis. Eventually, the fatigue cracks will become large enough to be detectable by means of non-destructive testing methods, i.e. dye penetrant, magnetic particle or ultrasonic. Periodic inspection is required to detect fatigue cracks that have grown to a significant size, in order to avoid serious failure in the crane structure.

The use of very ductile steel in KCI cranes, ensures that cracks are detectable by visual inspection, before fracture is likely. In many cases, even if fracture occurs, the remaining elements of the structure will prevent serious damage, if the crane is immediately taken out of service and repaired.



When a crack is found, a repair is necessary. Restoring the structure to its original condition is always acceptable. Sometimes, this is not practical, and a change in geometry by means of cutting and grinding is more economic.

Sometimes, fatigue cracks are found with a frequency significantly greater than would be expected, considering the stress levels used in the design. This may be caused by over stress in the crane during its operation. If such cracking is found, a review of the operation should be made, to see if over-stress is occurring. Remedial measures should be developed to avoid it in future.

1.2 Inspection Methods

In general, non-destructive testing (NDT) is sensitive to the external conditions and to the characteristics of the structure. Inspections must be carried out by qualified professionals using recognized methods.

If there is any suspicion of a crack, the weld must be examined thoroughly, so that the extent of the defect can be fully assessed.

1.2.1 Visual Inspection (VT)

Dirt and grease should be removed from surface by wiping with a rag. The surface should be inspected for cracked paint and rust showing through the paint. A good light (torch) and a magnifying glass should be used.

1.2.2 Magnetic Particle Inspection (MT)

The inspection should be done in accordance with a recognized procedure, e.g. ASTM E 709.

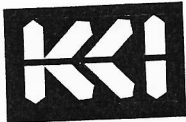
The test surface must be free from loose rust scale and moisture. An even paint layer may be left in place over the inspected surface, providing that the thickness does not exceed 100µm.

Note! If there is any doubt that the paint coating is affecting the test results, it must be removed from the inspection area.

Heavy grinding, brushing, or blasting may affect the results of this testing method in some instances.

A magnetic field can be applied to the test material using one of the following methods:-

1. A permanent magnet.



2. A yoke which includes an electro-magnetic device.

1.2.3 Ultrasonic Inspection (UT)

The testing should be done in accordance with approved standard methods.

Before this method can be used, the surface must be prepared to the required flatness and smoothness conditions.

The scanning can be done using suitable direct and / or angled probes.

The inspection results should provide detailed information about any defects within the volume of the weld, in addition to any surface cracks.

2 Inspection of Bolted Joints

2.1 Visual Inspection

At each yearly interval when the welded connections are subjected to visual inspection, all bolted joints in the structure must also be visually inspected.

For each joint, the visual inspection should include the following checks:-

1. The bolts and / or nuts are tight.
2. Any locking devices that prevent the bolts and / or nuts from coming loose, are fitted correctly.
3. There is no evidence of relative movement between the joint faces.

If a bolted joint fails any of these checks, all bolts and / or nuts in the joint must be tightened to the required level using the correct procedure, and then the locking devices must be fitted.

If there is any doubt that a bolt is seized or thread-bound and hence is not applying the force to the joint, the bolt must be replaced.

2.2 Bolt Torque Tightening

At the intervals when the welded connections are subjected to NDT inspection, all bolted joints in the structure must also be tightened to the required torque. A more detailed torque tightening procedures is given in Konecranes maintenance instruction HU 3.12.0170.



The tightening torque values can be converted to other common units, using the conversion factors ($1 \text{ Nm} = 0.738 \text{ lb}\cdot\text{ft} = 0.102 \text{ kpm}$).

3 Inspection for Corrosion

3.1 External Corrosion of Steel Structures

All steel structures are painted externally to prevent surface corrosion. Every year, the external surfaces must be visually inspected to ensure that the paint coating is intact.

In any areas where there is evidence of significant surface corrosion, the steel thickness must be checked.

3.2 Internal Corrosion of Box Type Beams

Even though the inspection hatches are tightly closed, some water may collect inside large box type beams. This is due to the condensation of the humidity in the air during daily ambient temperature cycles. The moisture may lead to the internal corrosion of the box section beams.

The inside of all such beams must be visually inspected on a periodic basis, at the same interval as the NDT tests. Where there is evidence of significant corrosion, the thickness of the plate must be measured accurately.

When the inspection is completed, the access hatches must be re-fitted using new seals.

3.3 Acceptable Corrosion

The maximum allowable reduction in plate thickness varies between 5% and 15% of the original thickness, mainly depending on the extent of the corroded area.

Any areas where the corrosion exceeds these levels must be repaired using an acceptable procedure.

3.4 Re-Painting of Surface Coatings

Any defective areas of the surface paint coating must be made good to the original specification. This includes all areas where structural repairs have been made.



Before patch painting, any loose or cracked surface coating must first be removed, and any surface rust cleaned off by wire brushing.

4 Frequency of Inspection

Year	Inspection
1 – 4 (see note 1)	Yearly visual inspection: Yearly after start-up visual inspection of all welds indicated in the diagrams, this includes the welds that are subject to NDT on certain years. Visual inspection of bolted joints and external corrosion.
5	Full structural inspection: After five years since start-up, the first full-scale NDT of welds must be carried out. The inspection diagrams list the welds that are subject to this requirement. Visual inspection of external corrosion. Inspection for internal corrosion of box type beams. Bolted joints are subject to torque tightening.
6 – 14 (see note 1)	Yearly visual inspection
15	Full structural inspection is repeated ten years after the first one.
16 – 24 (see note 1)	Yearly visual inspection
25, 30, etc.	Full structural inspection is carried out after 25 years, and then repeated every five years.
26 - 29, etc. (see notes 1, 2)	Yearly visual inspection

Note 1. If the visual inspections give reason to suspect excessive crack growth, additional NDT inspections must be carried out. These additional test requirements are restricted to the specific welds that are showing crack growth.

Note 2. After 25 years since start up, the NDT results for some weld details may show that there are a significant number of new cracks since the previous NDT inspection. For these welds, the NDT must be repeated every year, for the remaining life of the Crane.



5 Reporting and Repairs

5.1 Reporting Procedure

Every detected crack or indication of an internal defect must be reported! When a crack or defect is found, a repair is always necessary.

The owner of the crane is responsible for keeping complete records of all inspections. Where defects are found, the owner must ensure that the repair is made. The complete history of all defects, repairs and subsequent re-inspections must be maintained for the full operational life of the crane.

The manufacturer should receive reports of the results of any structural inspection for comparison with other similar structures throughout the world. In particular, these should include photographs or sketches showing indications of defects if any are evident, stating the following:-

1. Location - right hand side, left hand side, north, south, east, west, etc.
2. Size of defect.
3. Extent of defect
 - a) In the toe of the weld.
 - b) Propagating into the base metal.
 - c) Any other notes.
4. Method of testing.

5.2 Repair Procedure

Inform the manufacturer (Konecranes) of all structural repairs made to the crane.

If re-welding is proposed, the repairer shall satisfy himself that the weld repair to the structure is practical. All repair procedures containing welding shall be agreed with the manufacturer.

CAUTION!
No additional strengthening brackets or similar attachments may be welded to the structure, without the written permission from the manufacturer.

Note! The arc welding current can damage anti-friction bearings. Always fix the welding circuit return conductor directly to the structure being welded and connect temporary large section earth conductors across any anti-friction bearings that could be affected.



If a design modification is required, the instructions must be asked from the manufacturer.

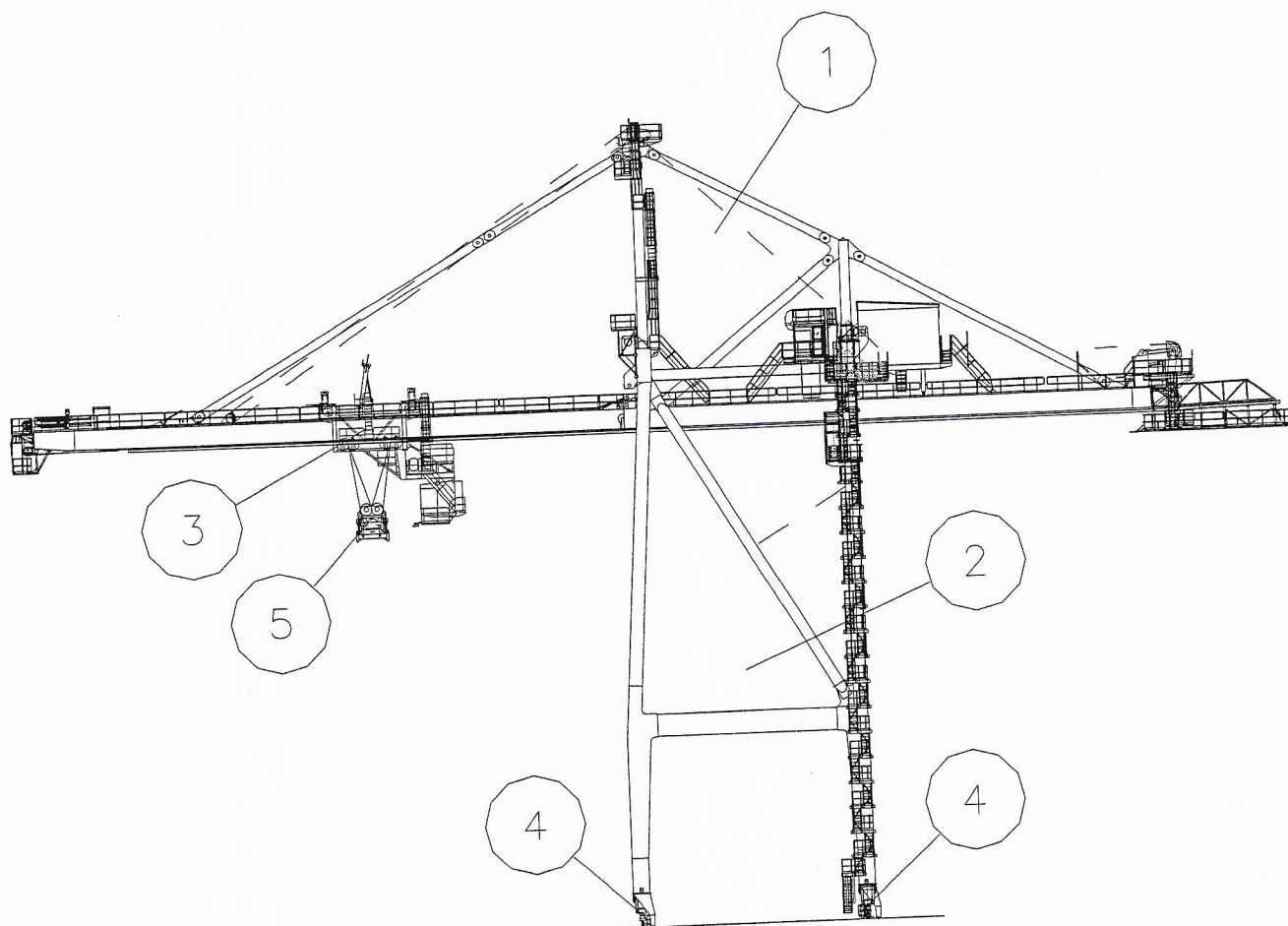
6 Structural Inspection Plan

The inspection plan is made up as a number of diagrams of the structural details. Each diagram shows which welds need to be inspected, and the recommended inspection method. Additionally, requirements for inspection of bolted and pin joints are shown.

The diagrams give only an overall picture of the welds. With complicated welds or when using an actual NDT-method (UT, MT, RT) the inspector must find out the real weld construction from the manufacturing drawings.

In many cases, the inspection plan may highlight only one or two instances of a structural member detail. However, the same detail may be repeated many times in the crane. The actual inspection must be extended to all instances of a similar detail, e.g. symmetrical details, both ends of a member, etc.

In some cases only a given percentage of the weld length is required to be inspected. If defects are found in this limited part of the weld, the inspection must be extended to cover the whole weld length.



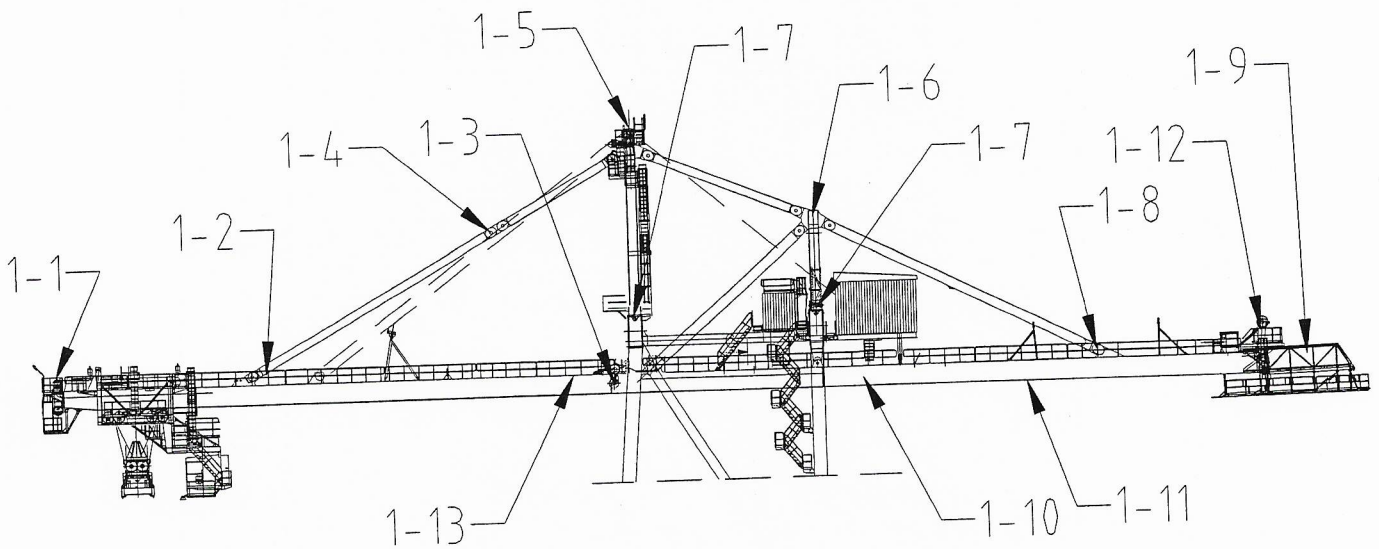
Inspection Plan – Container Crane

The inspection plan is divided into eight subsections:

1. Upper Part
2. Portal
3. Trolley
4. Bogies
5. Headblock



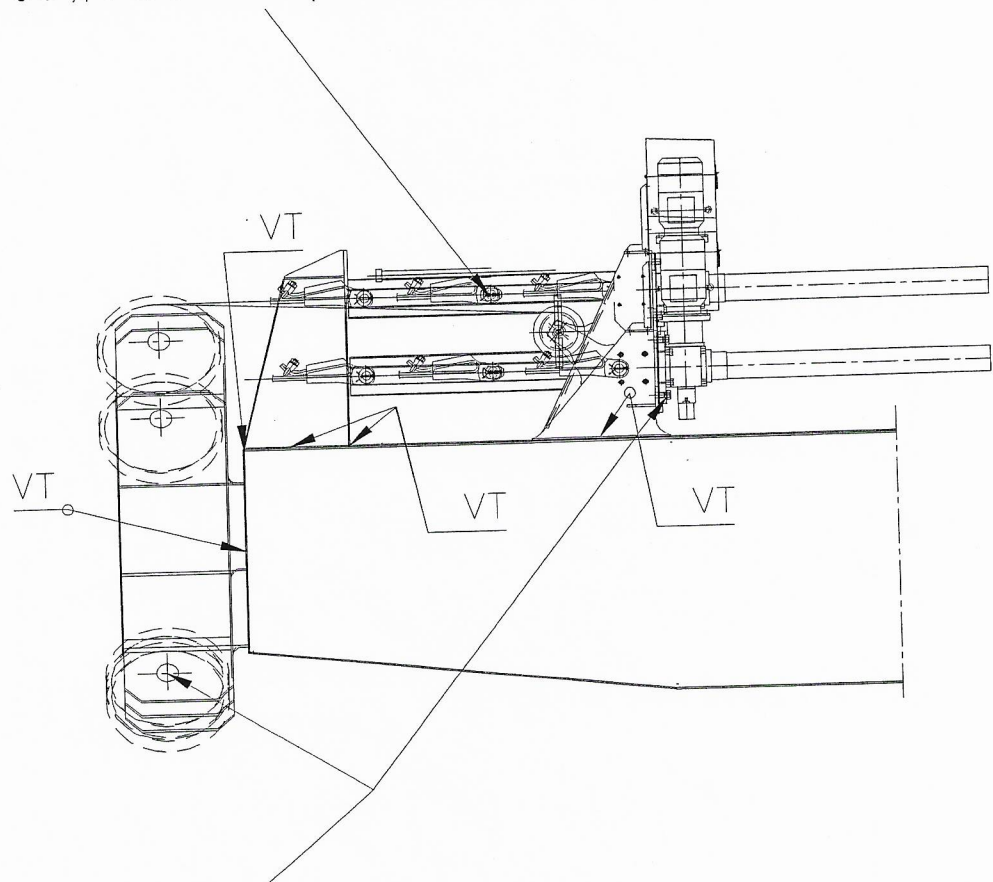
6.1 Upper Structures



Inspection Plan – Upper Structures



Check the condition and fixing of bolts,
wedge socket and axle..

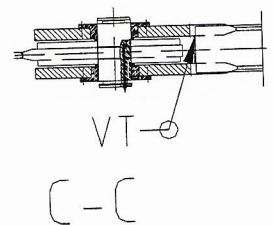
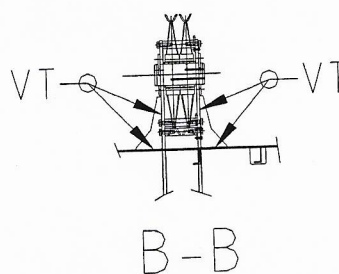
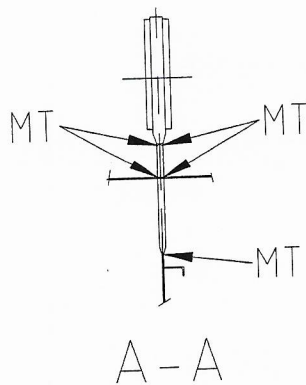
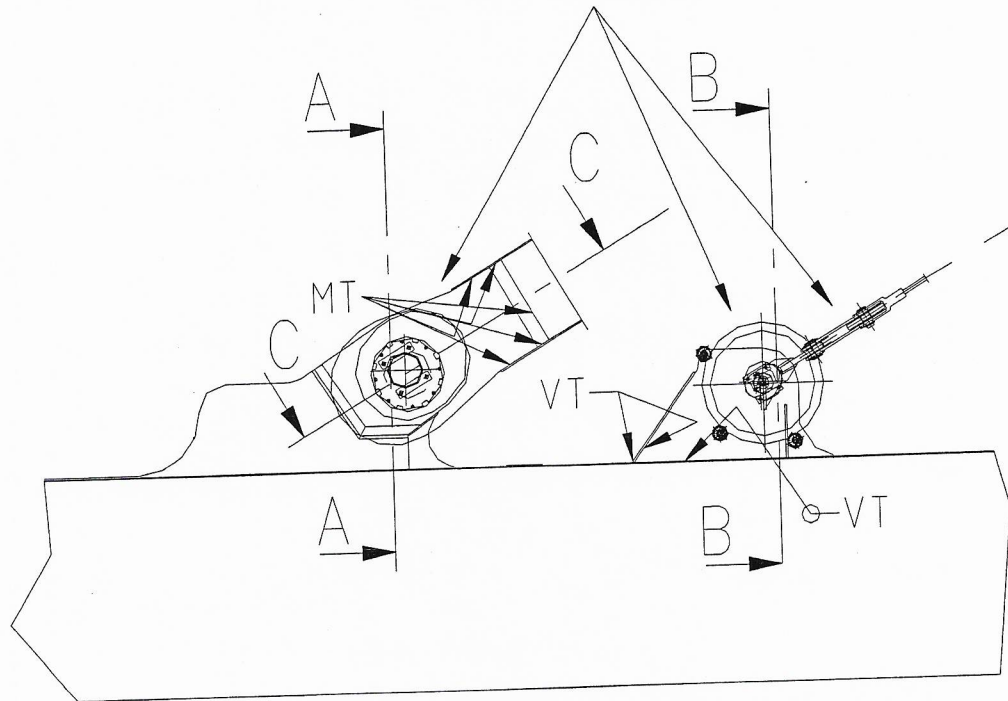


Check the condition of bolts and axleholders

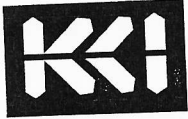
Detail 1-1 – Boom end Beam



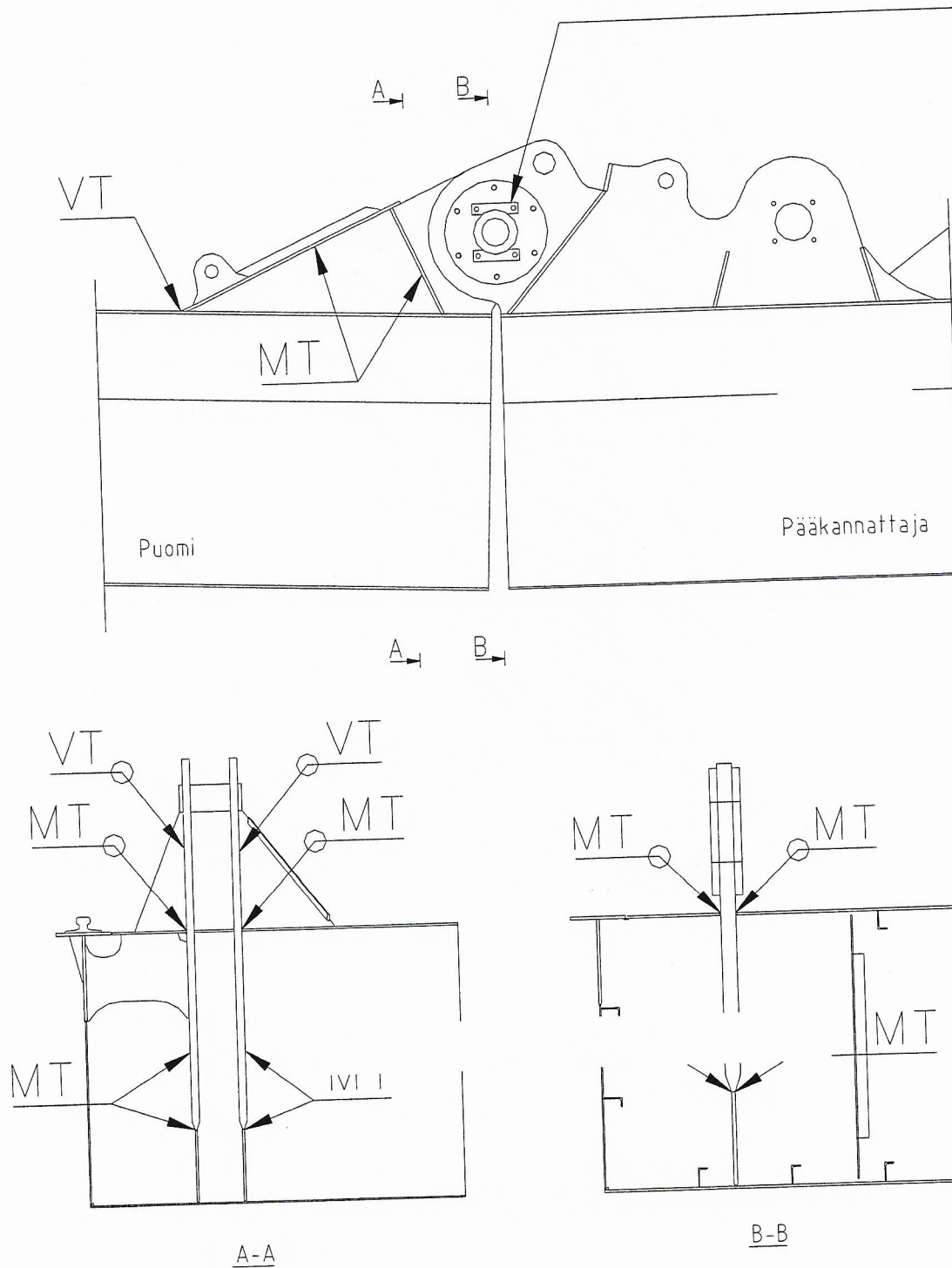
Check the condition of
bolts and axle holders.



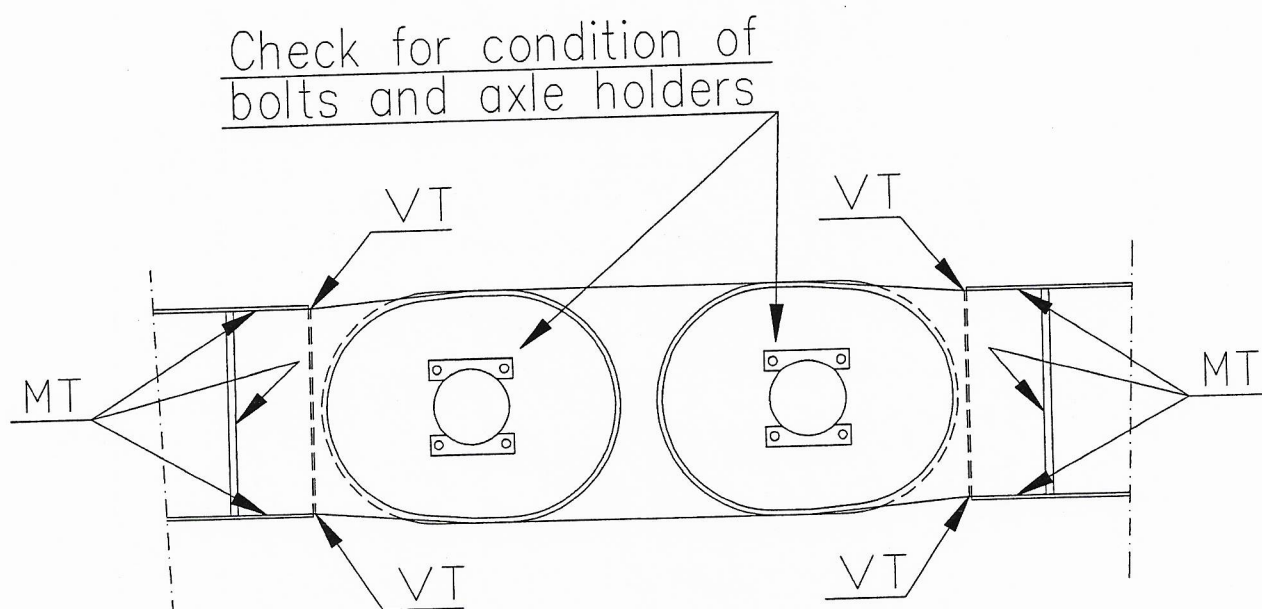
Detail 1-2 - Pulley Support, Lower end of Stay.



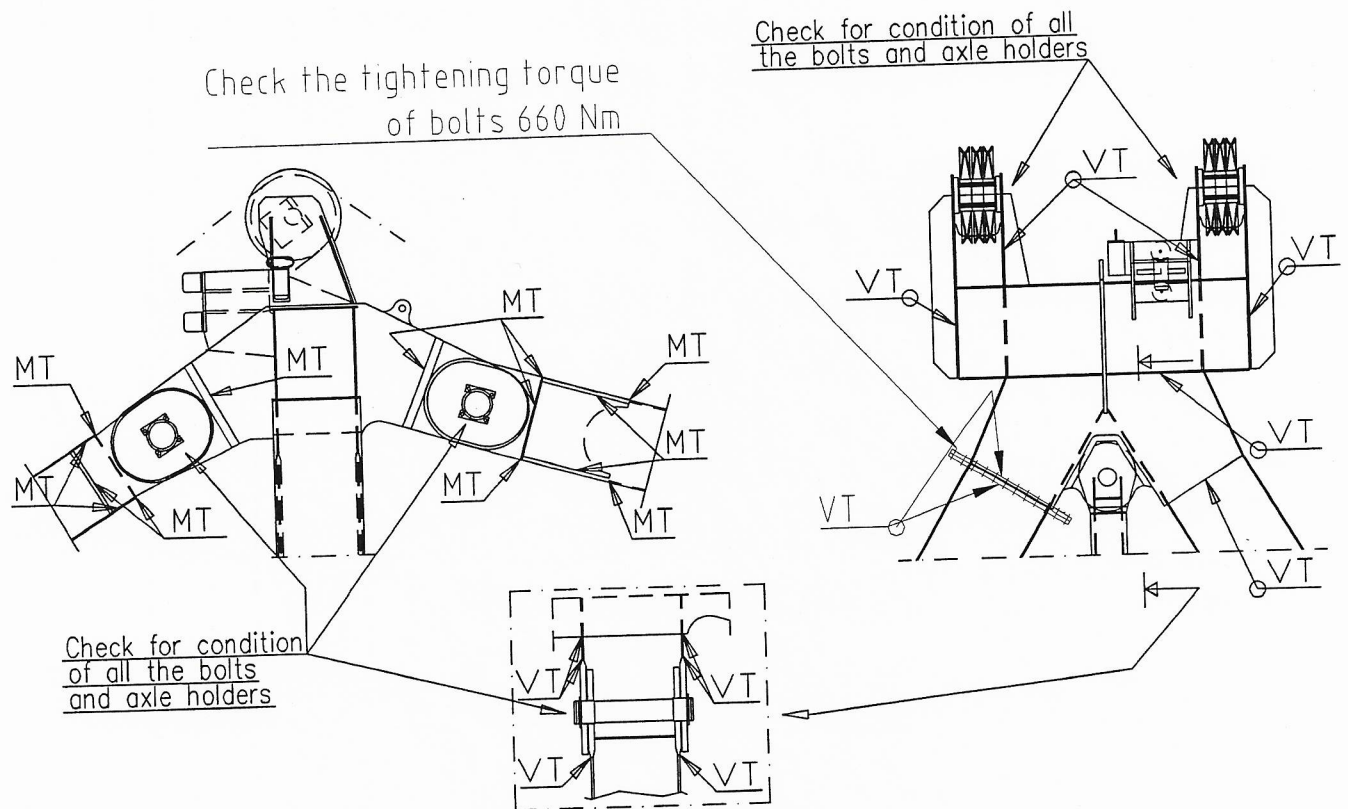
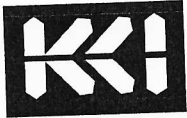
Check the condition and fixing
of bolts and axle holders



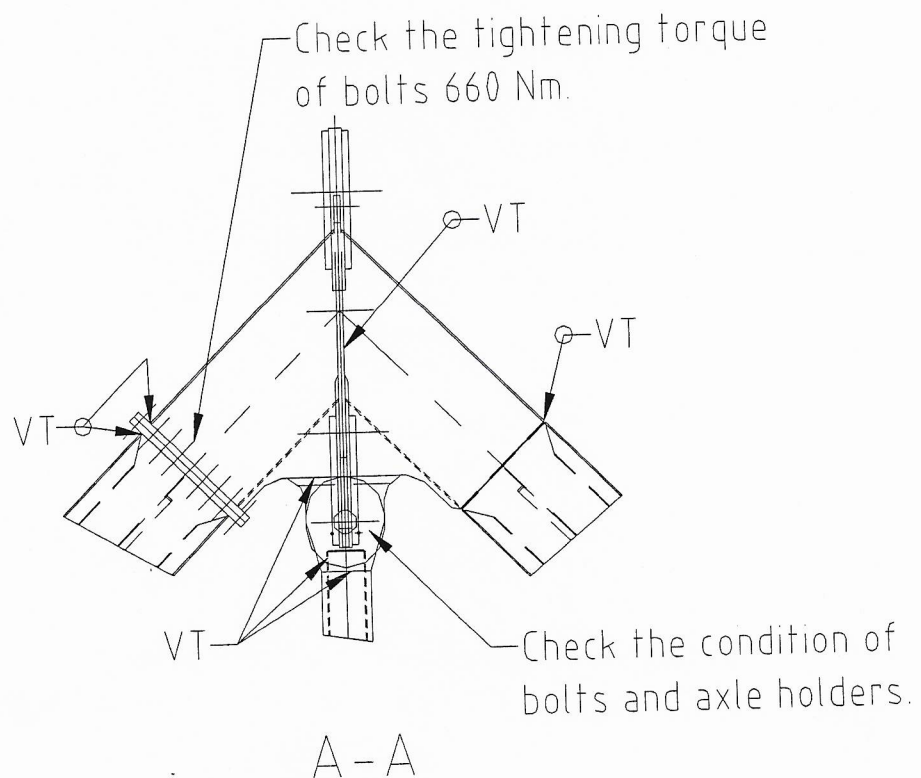
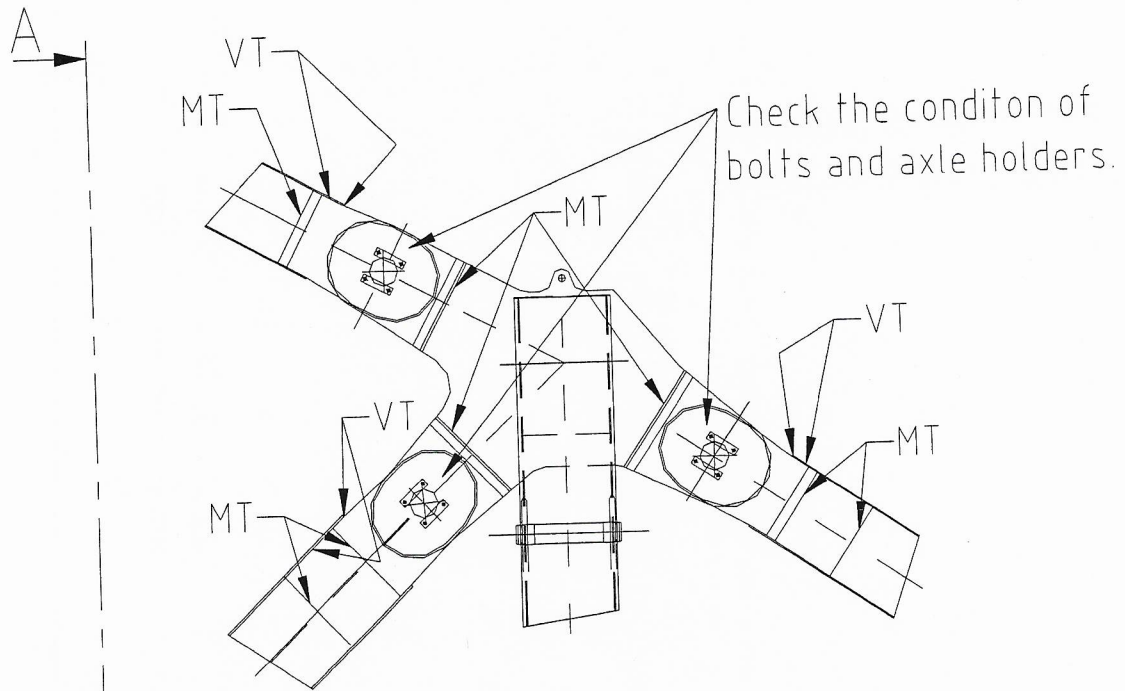
Detail 1-3 - Boom Hinge



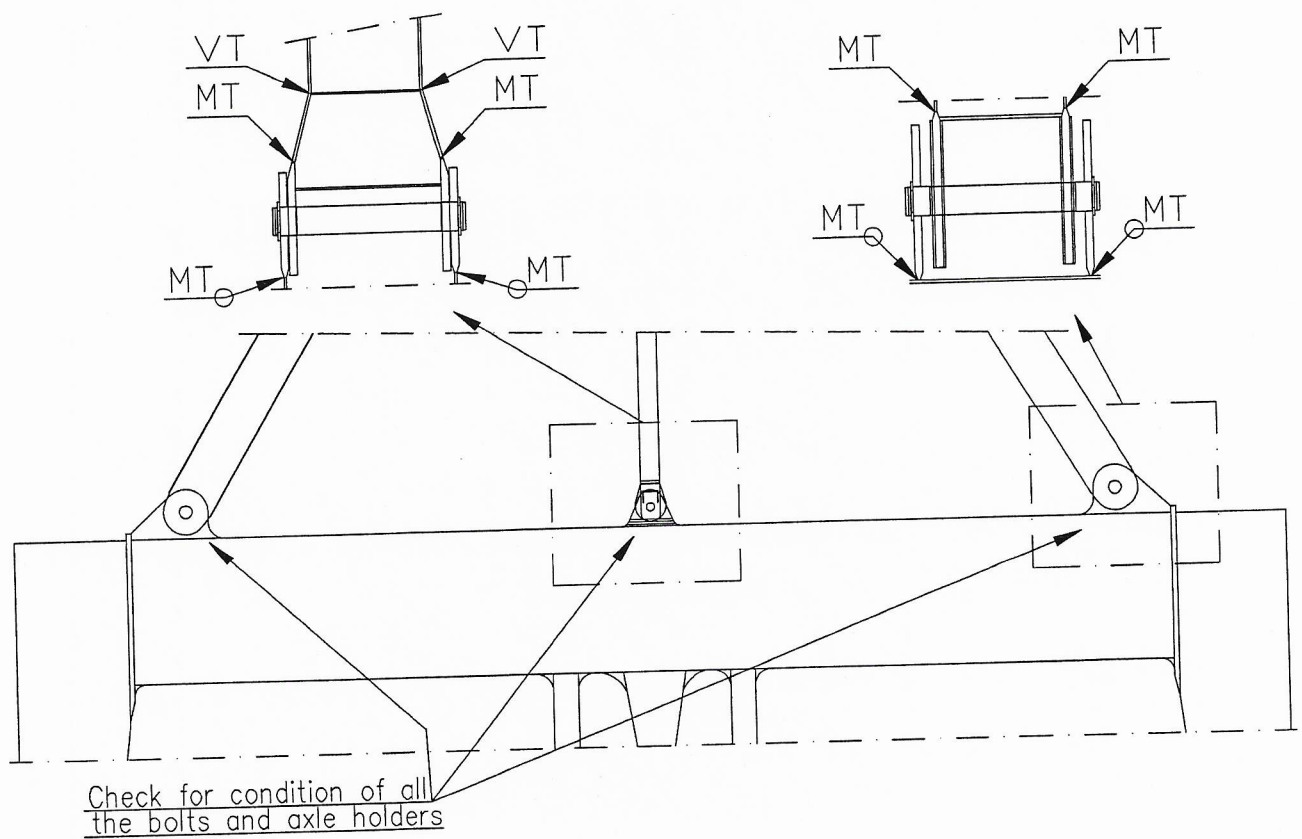
Detail 1-4 - Middle Part of Front Stay



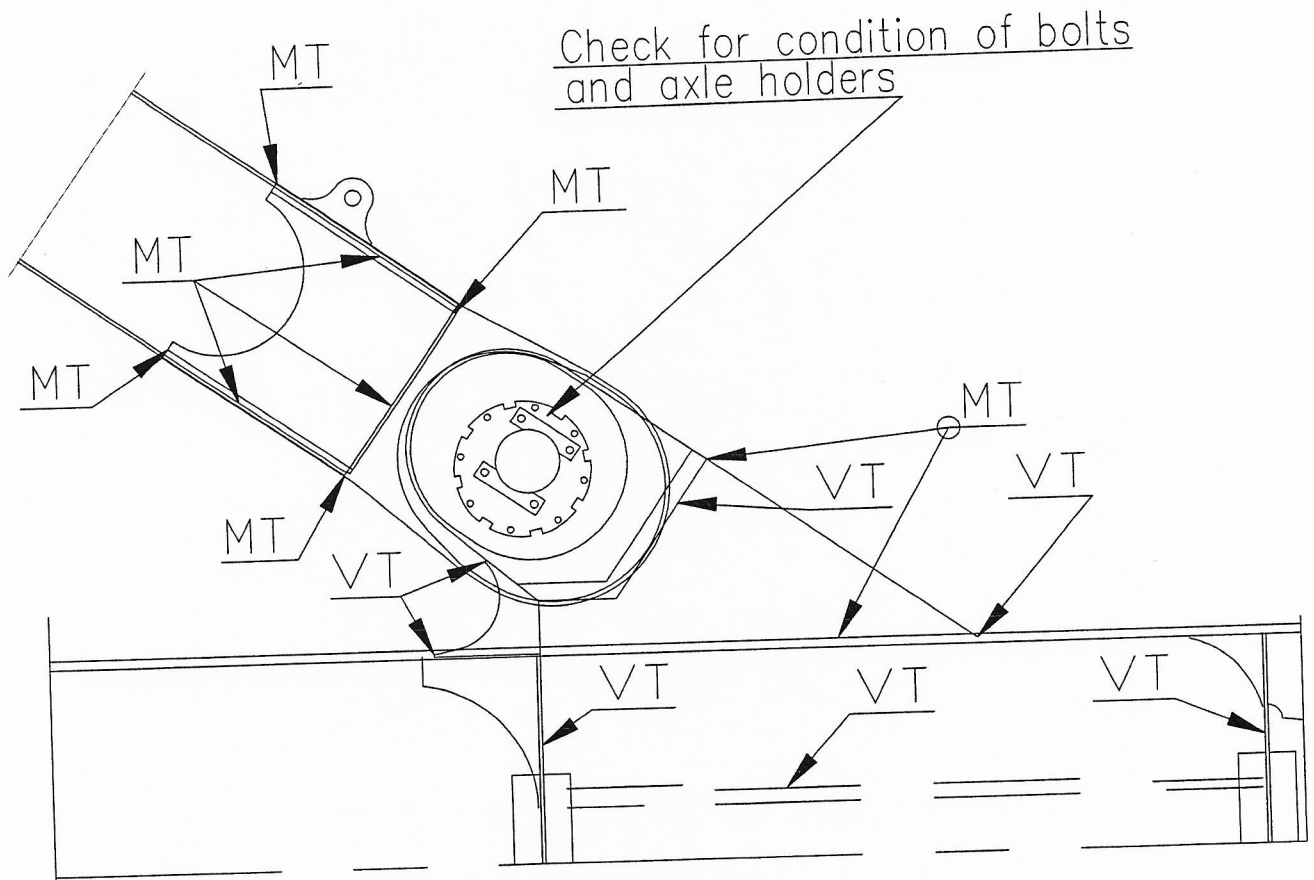
Detail 1-5 - Top of Front Pylon



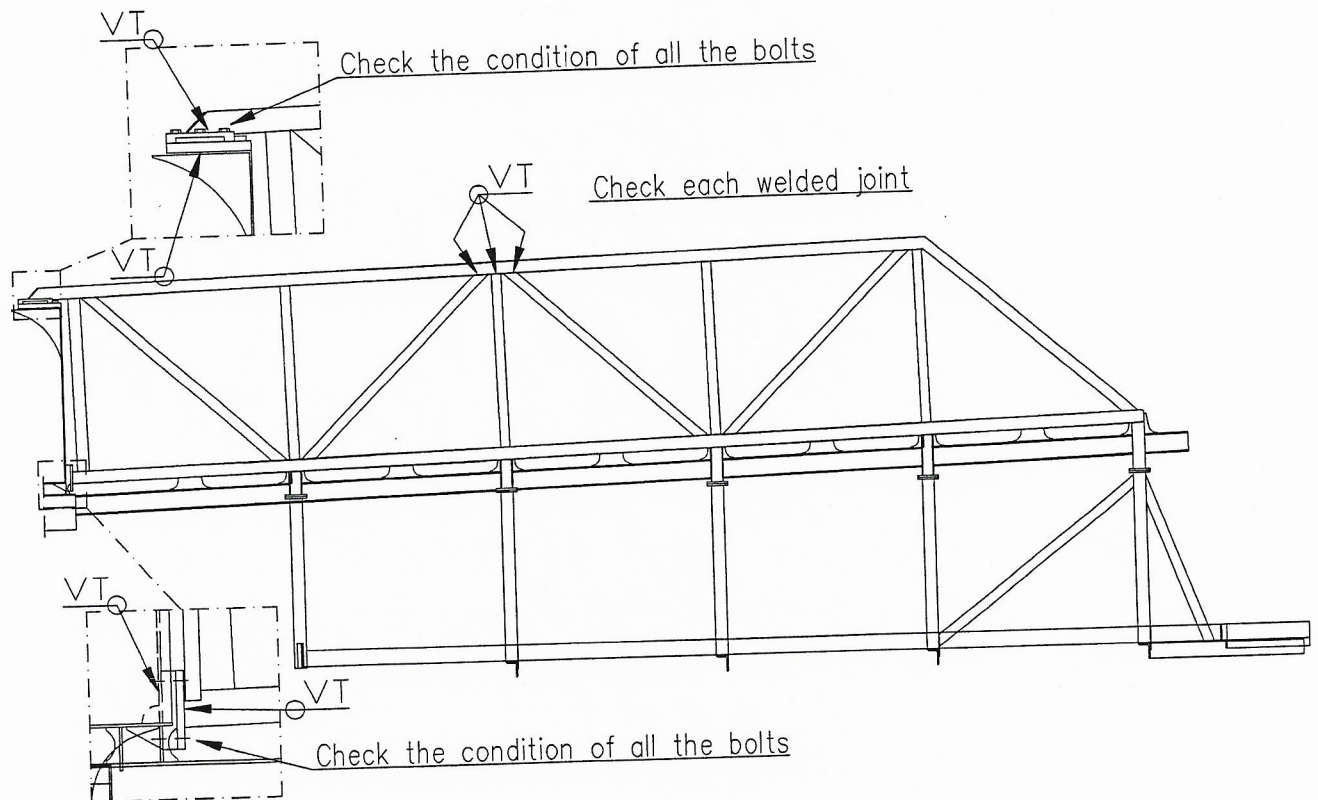
Detail 1-6 - Top of Back Pylon



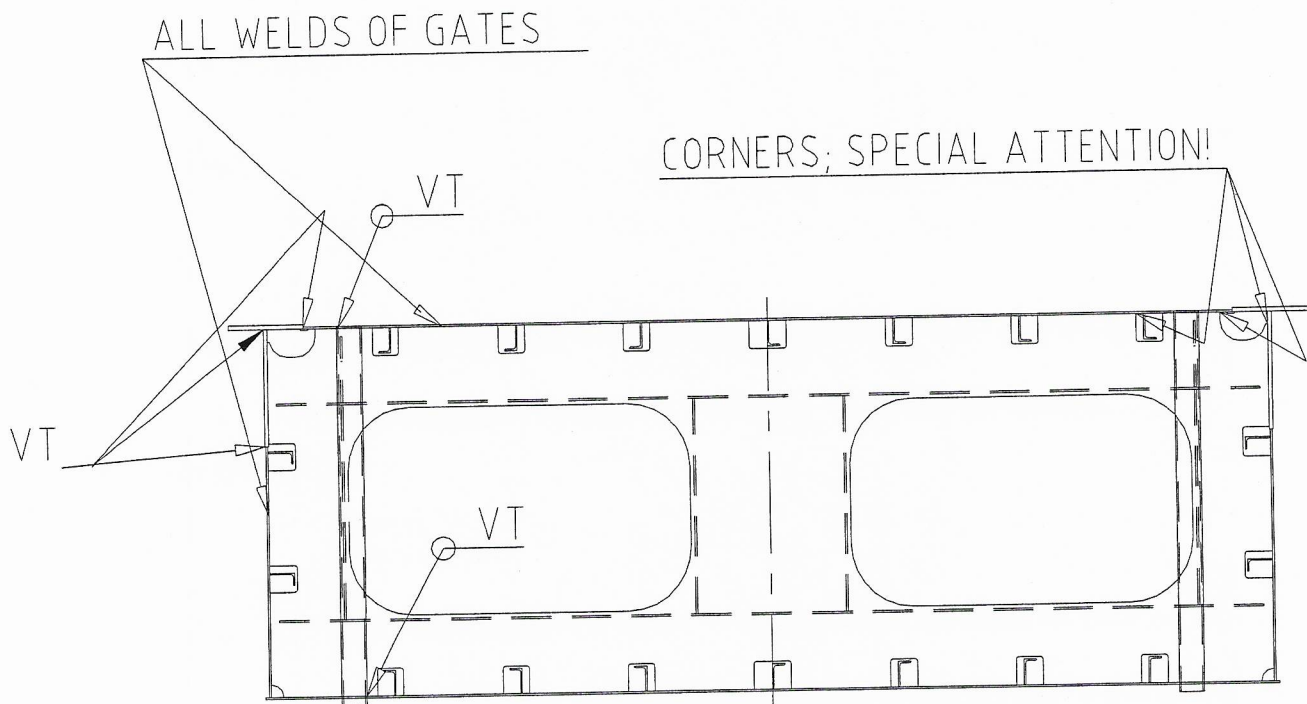
Detail 1-7 - Joints of Pylon and Portal



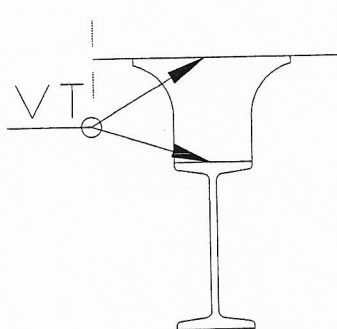
Detail-1-8 - Lower end of Back Stays



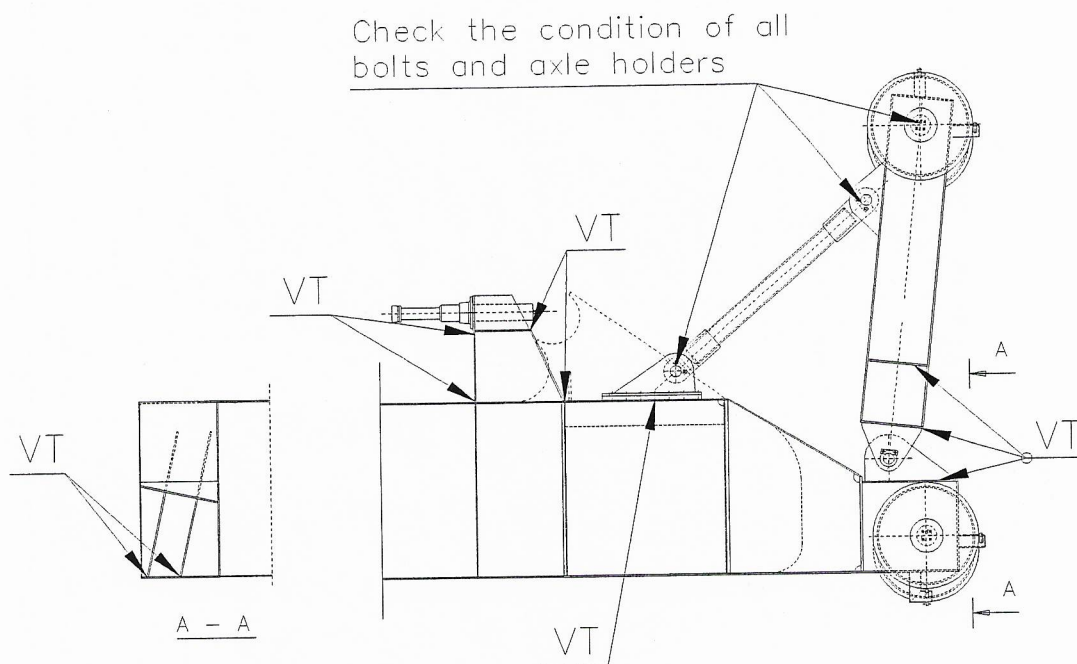
Detail 1-9 - Festoon Support



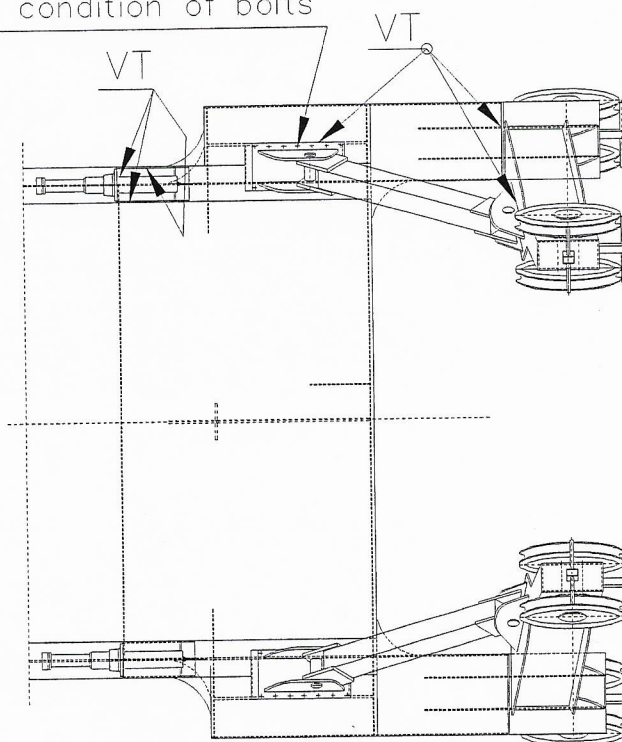
Detail 1-10 - Main Girder & Boom Diaphragms



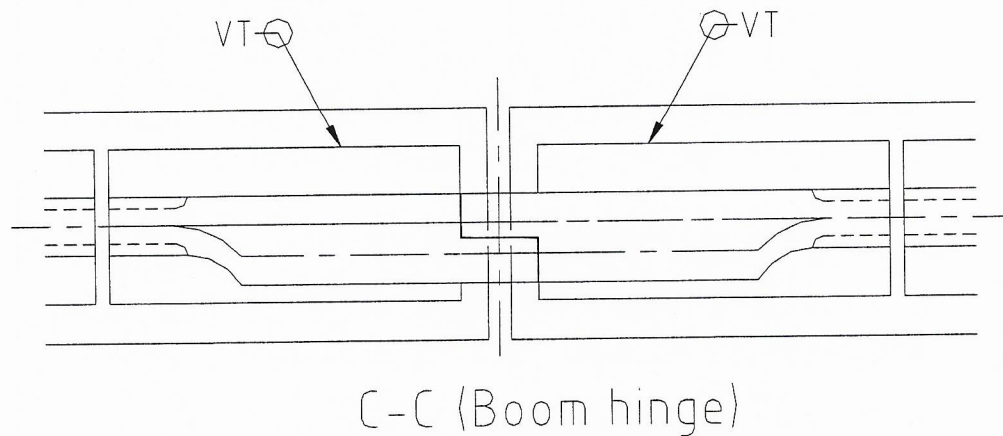
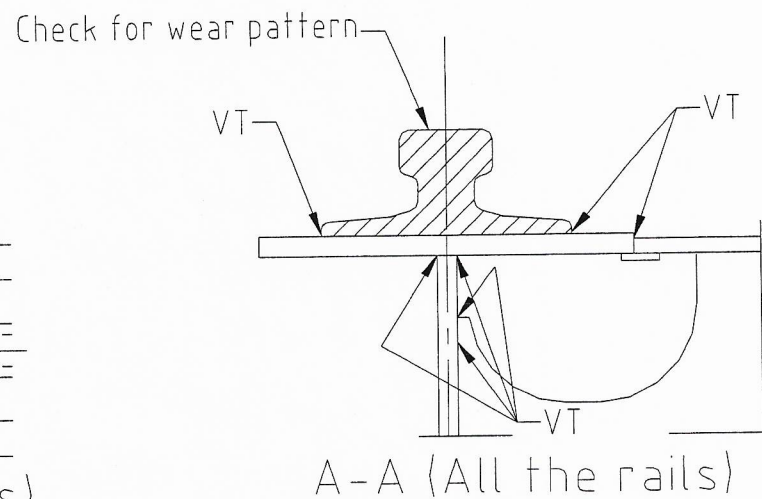
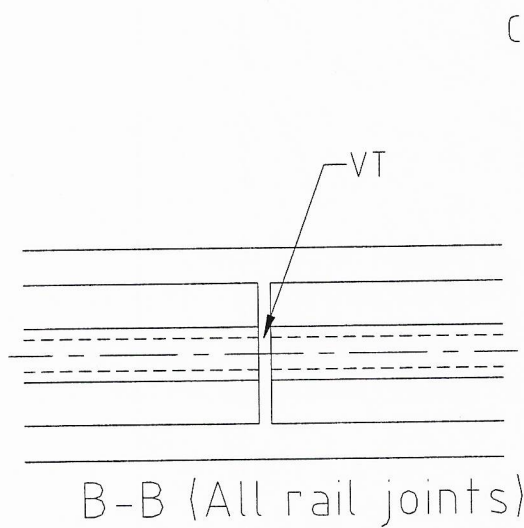
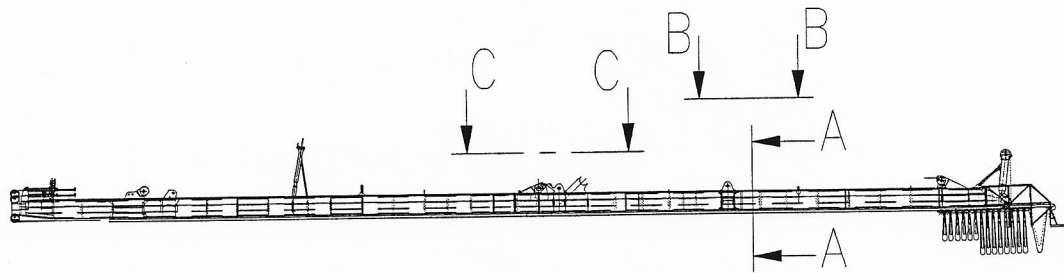
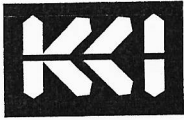
Detail 1-11 - Joints of Festoon Rail



Check the condition of bolts



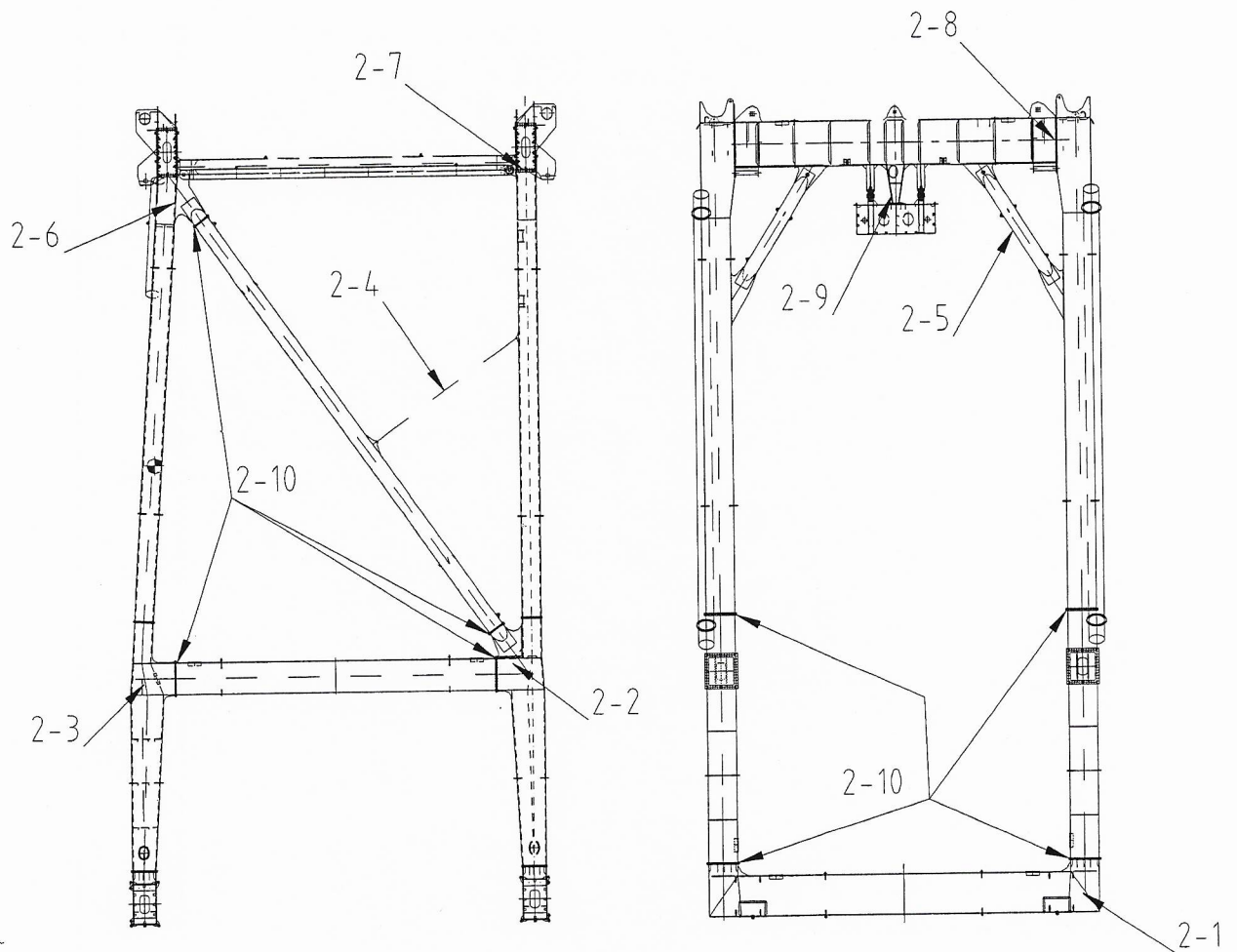
Detail 1-12 - Rear of Main Girder



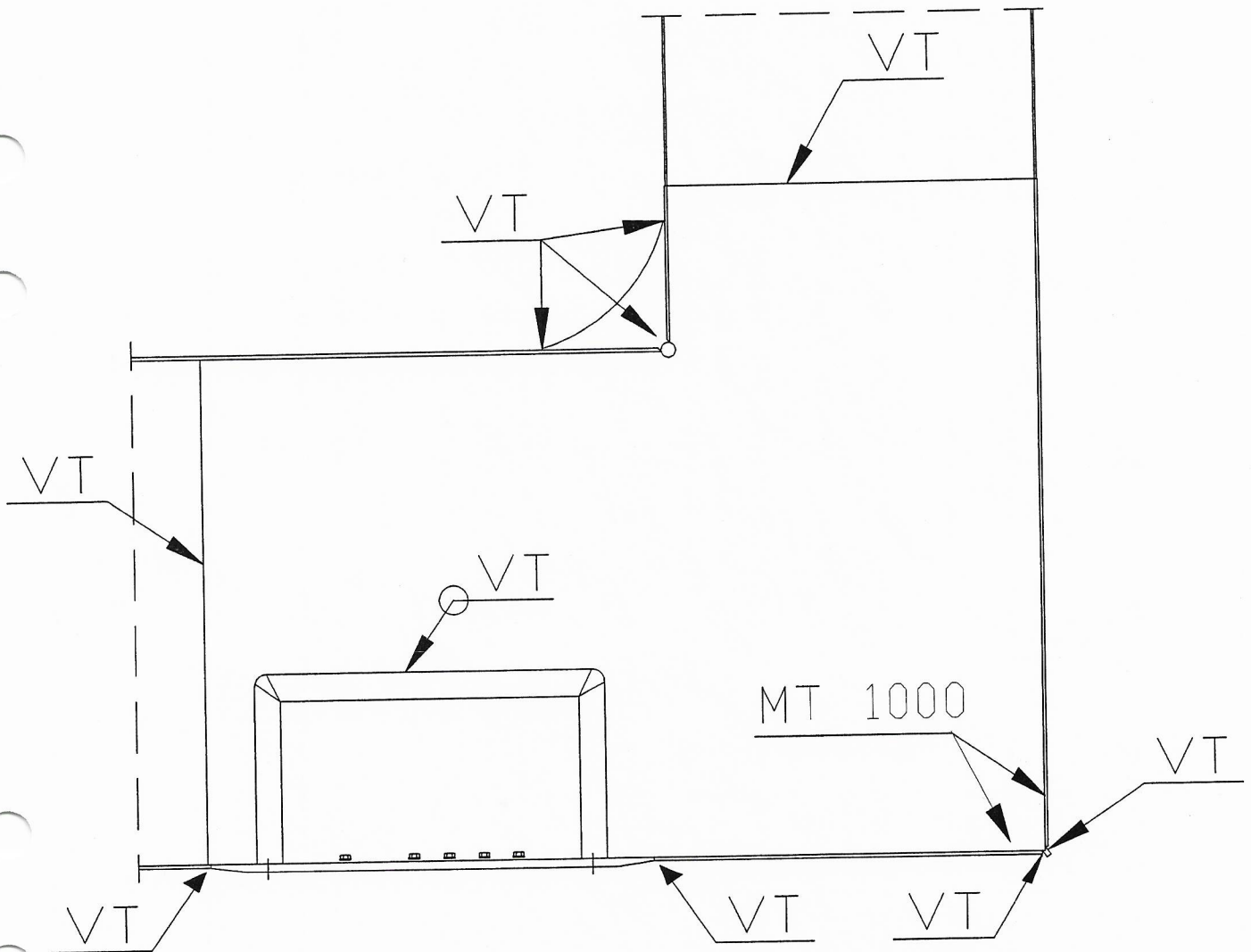
Detail 1-13 – Trolley Rails on the Boom & Main Girder



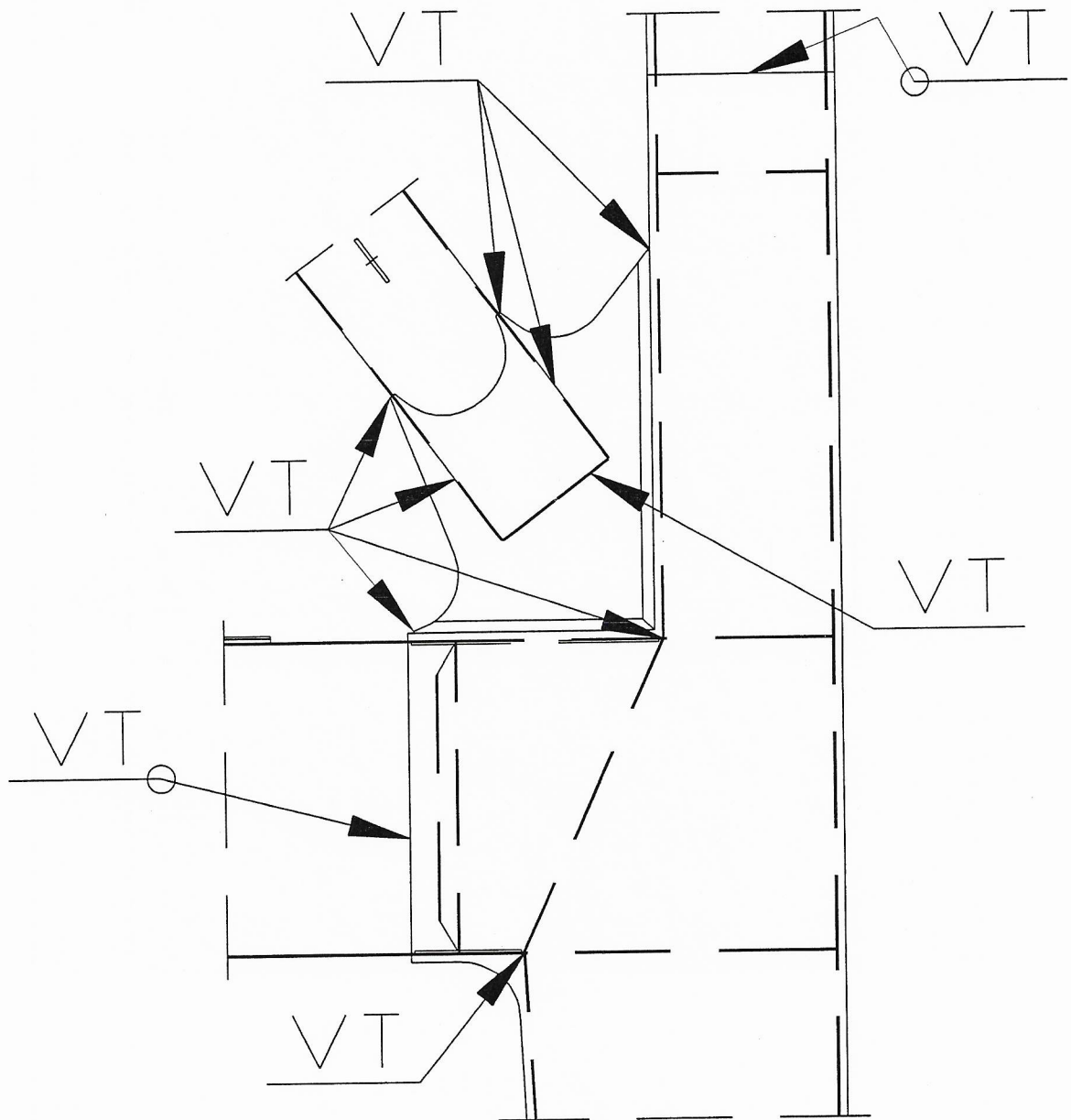
6.2 Portal



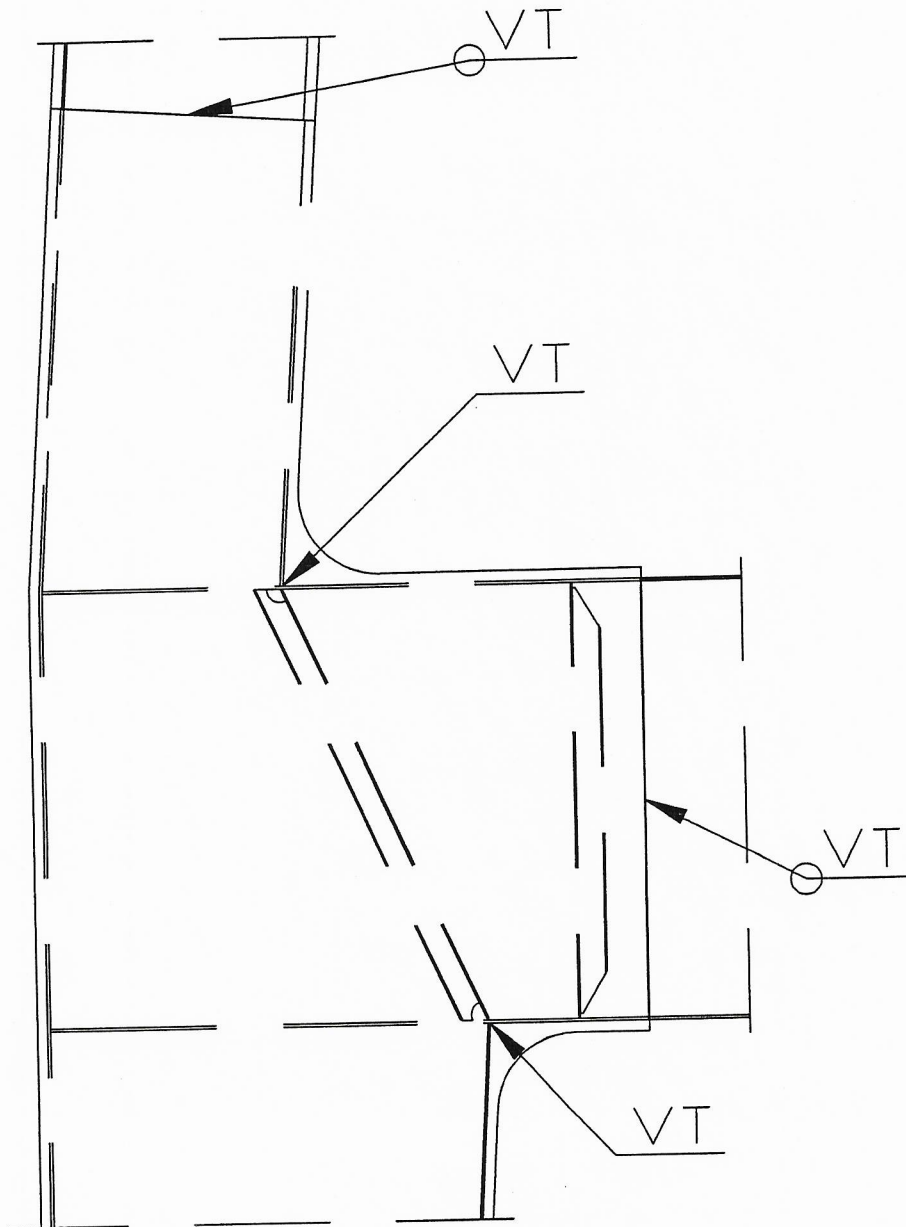
Inspection Plan – Portal



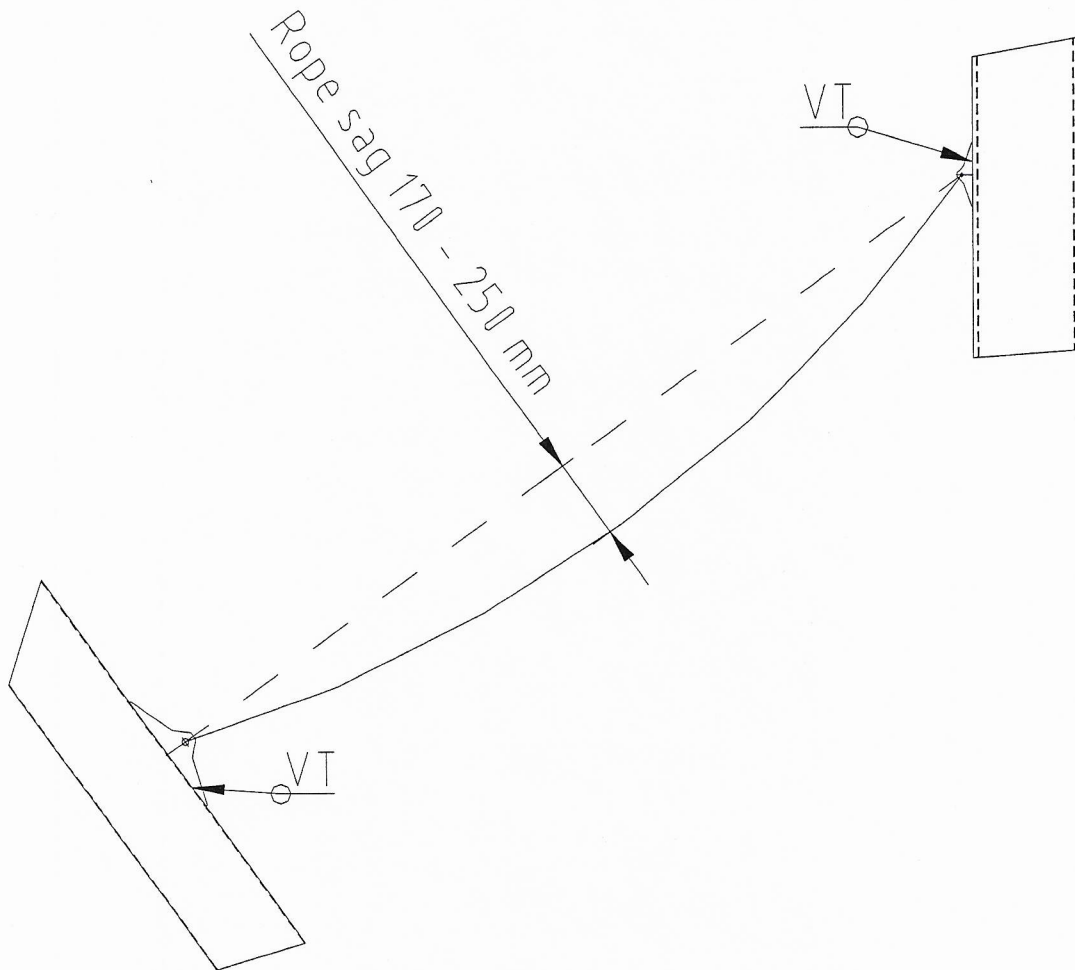
Detail 2-1 - Joints of Leg and Sill Beam



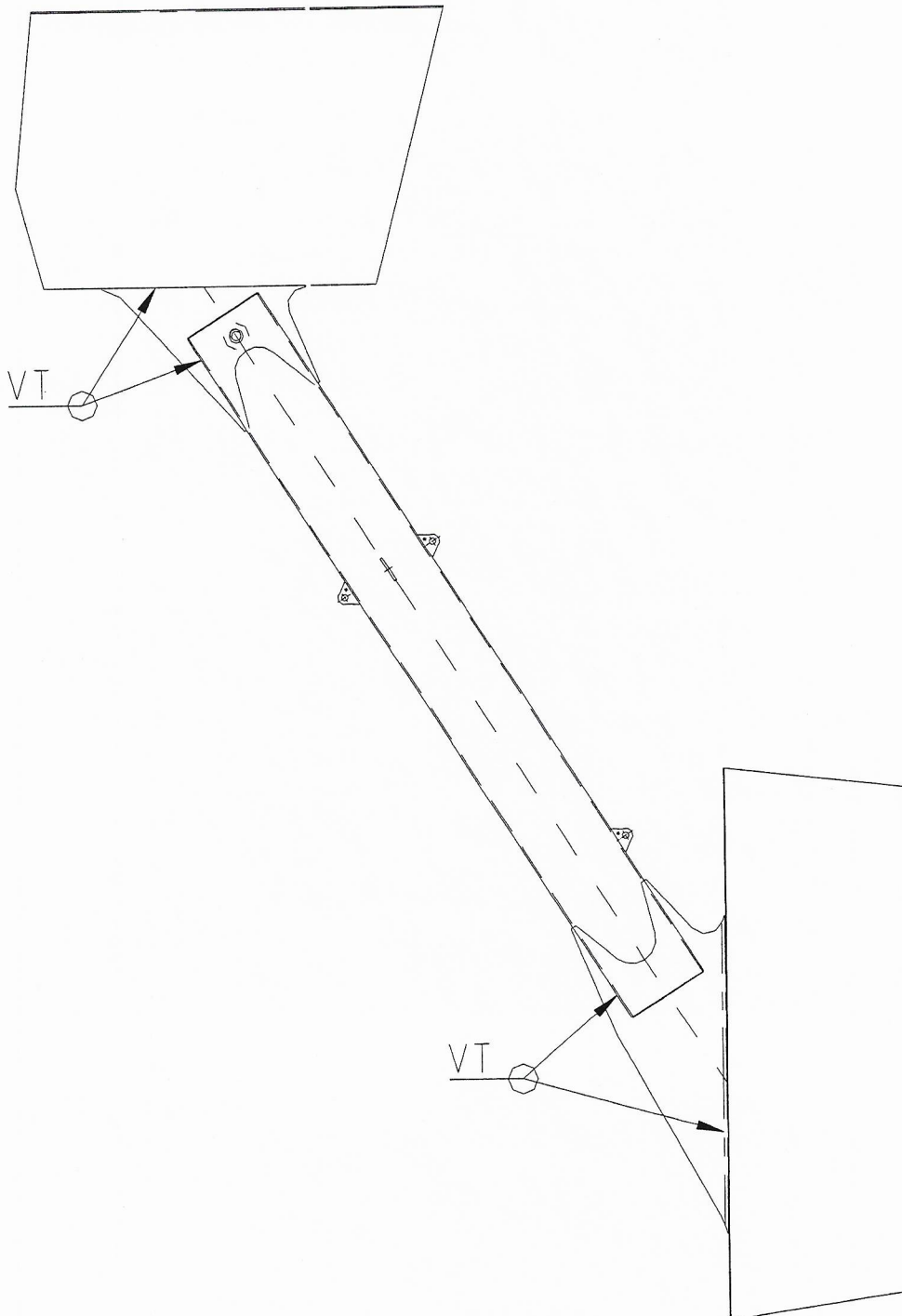
Detail 2-2 - Joints of Landside Leg, Horizontal Beam and Diagonal



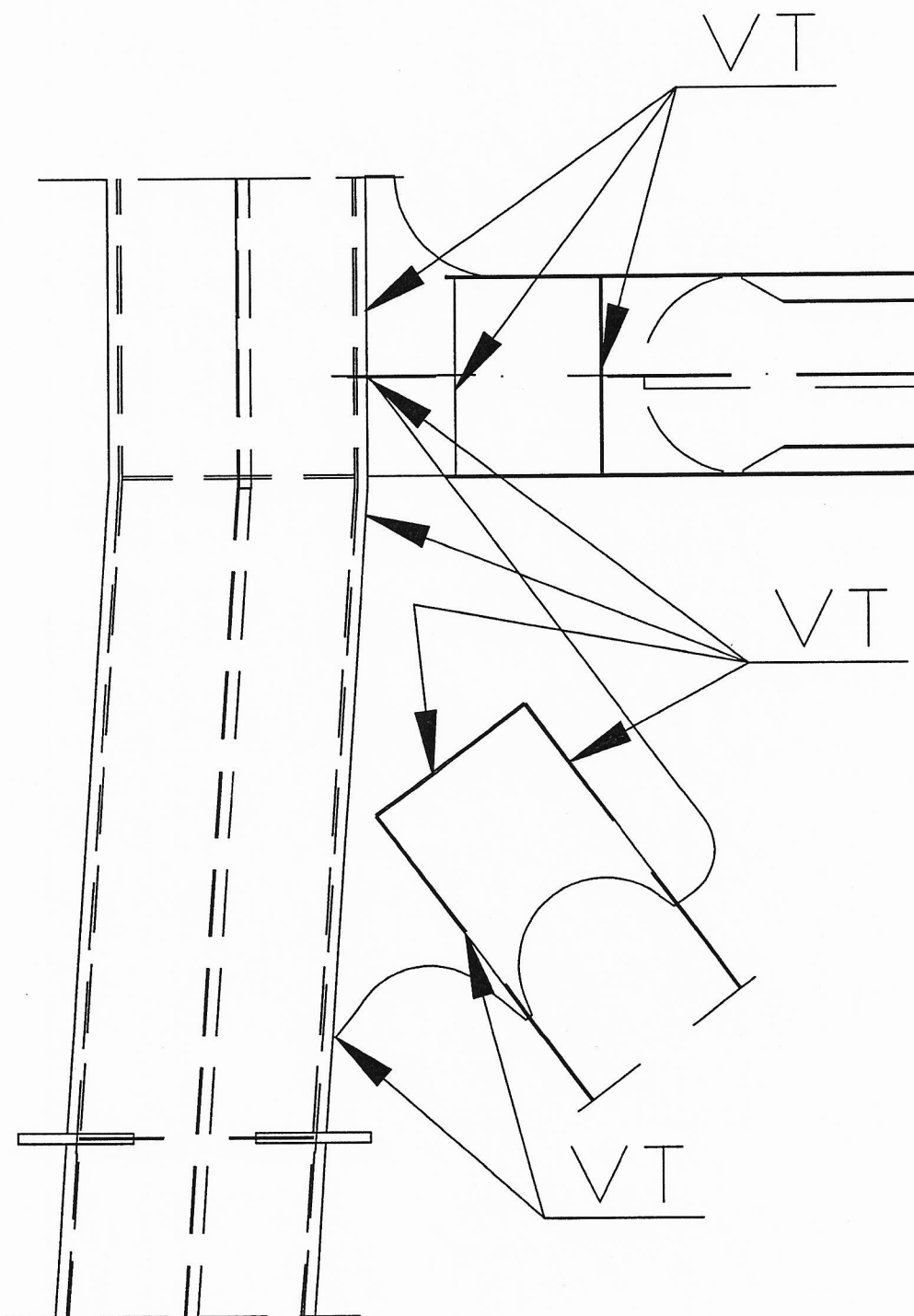
Detail 2-3 - Joints of Seaside Leg and Horizontal Beam



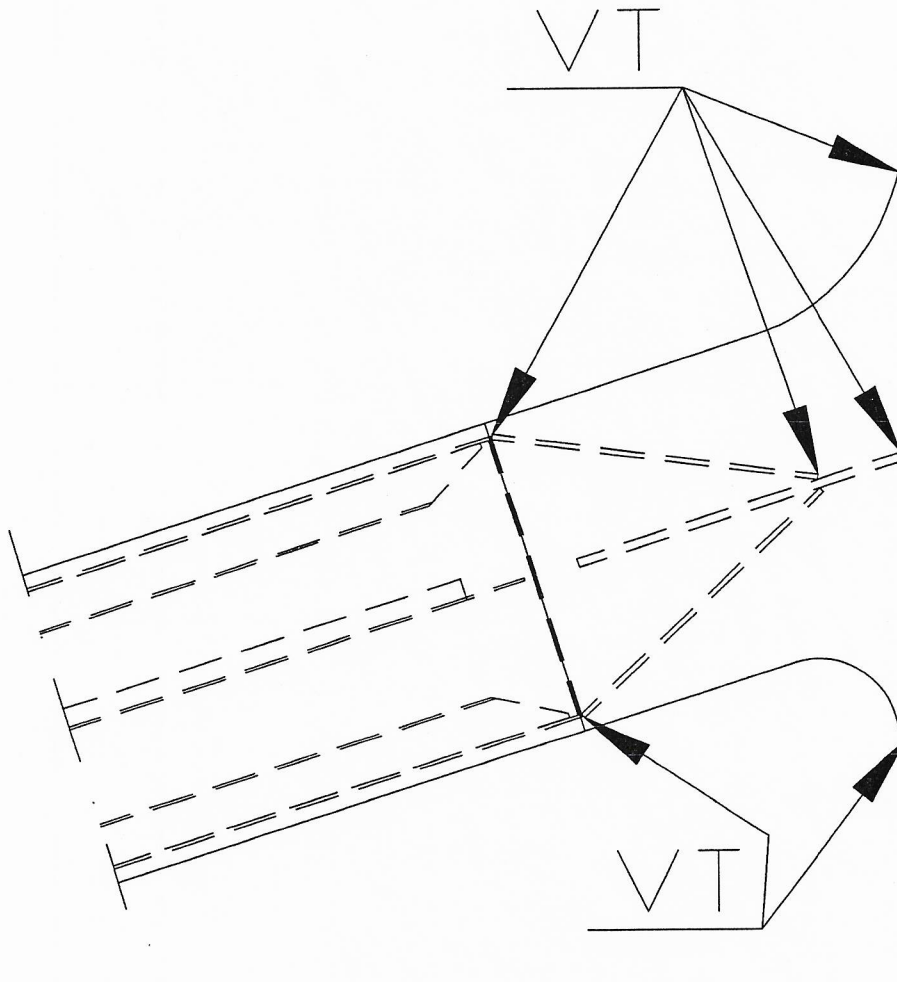
Detail 2-4 – Damping rope



Detail 2-5 – Diagonal



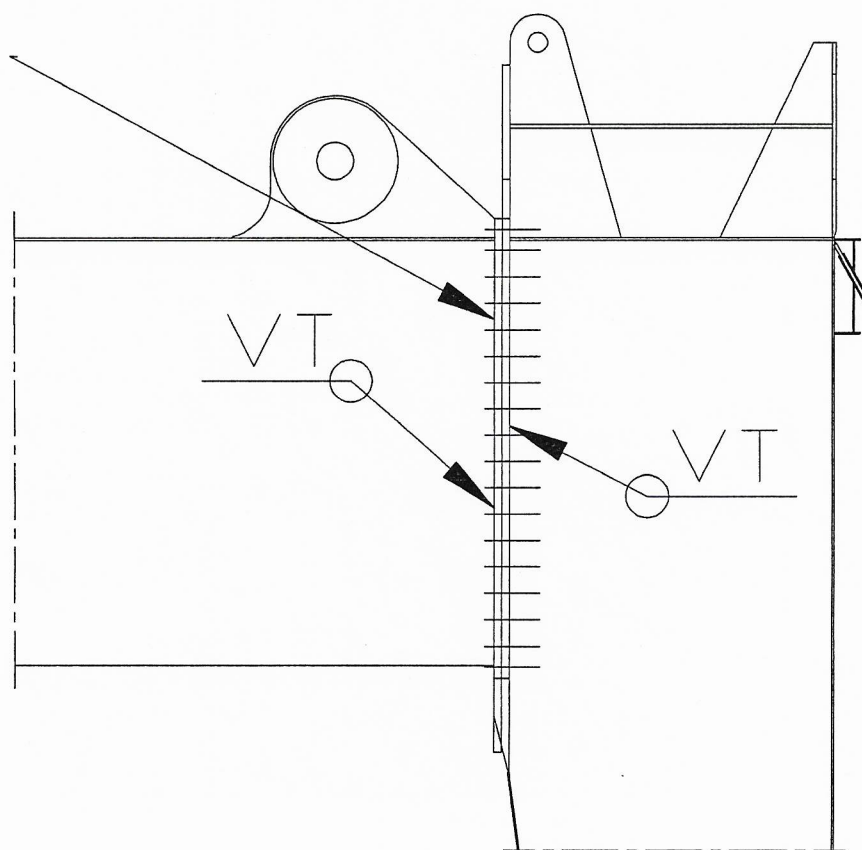
Detail 2-6 - Joints of Front shoulder beam, Leg, Diagonal and Support Beam



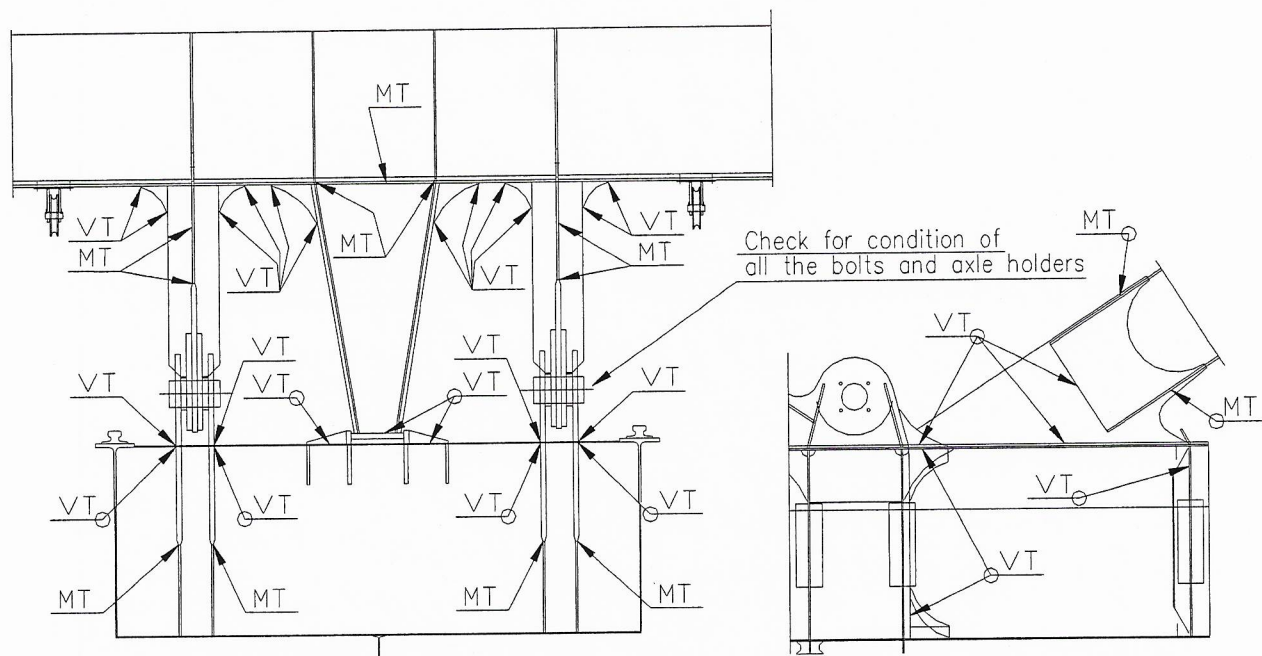
Detail-2-7 - Joints of Back Shoulder Beam and Support Beam



Check for condition of all the bolts
Tightening torque $M = 710\text{Nm}$

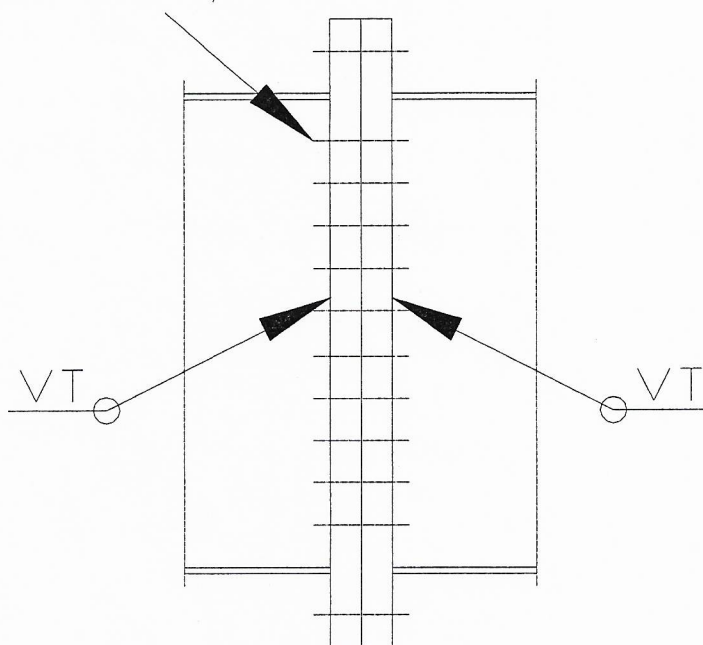


Detail 2-8 - Joints of Leg and Shoulder Beam



Detail 2-9 - Joints of Front Shoulder Beam and Main Girder

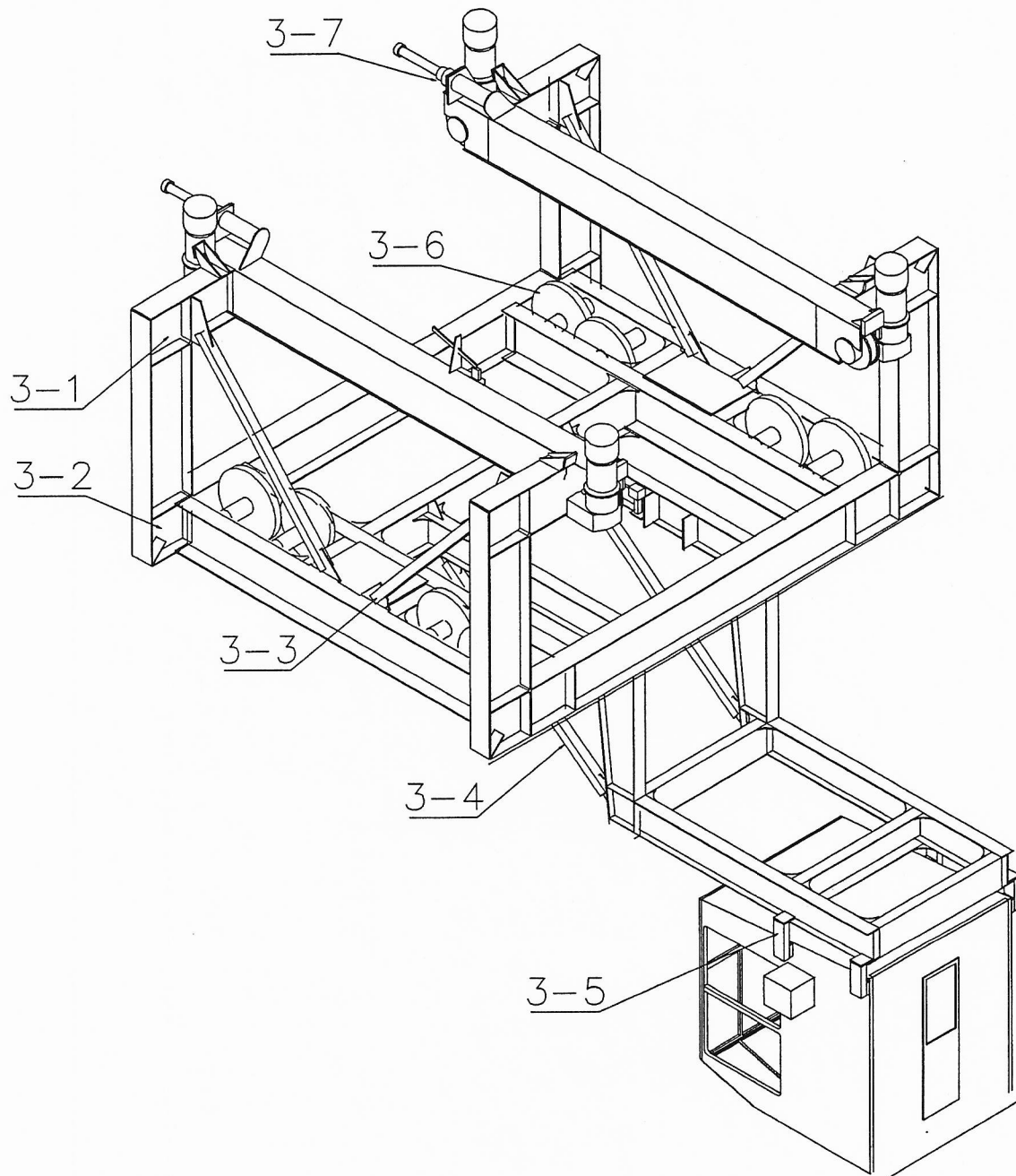
Check the condition and
tightening torque of bolts, $M=660 \text{ Nm}$



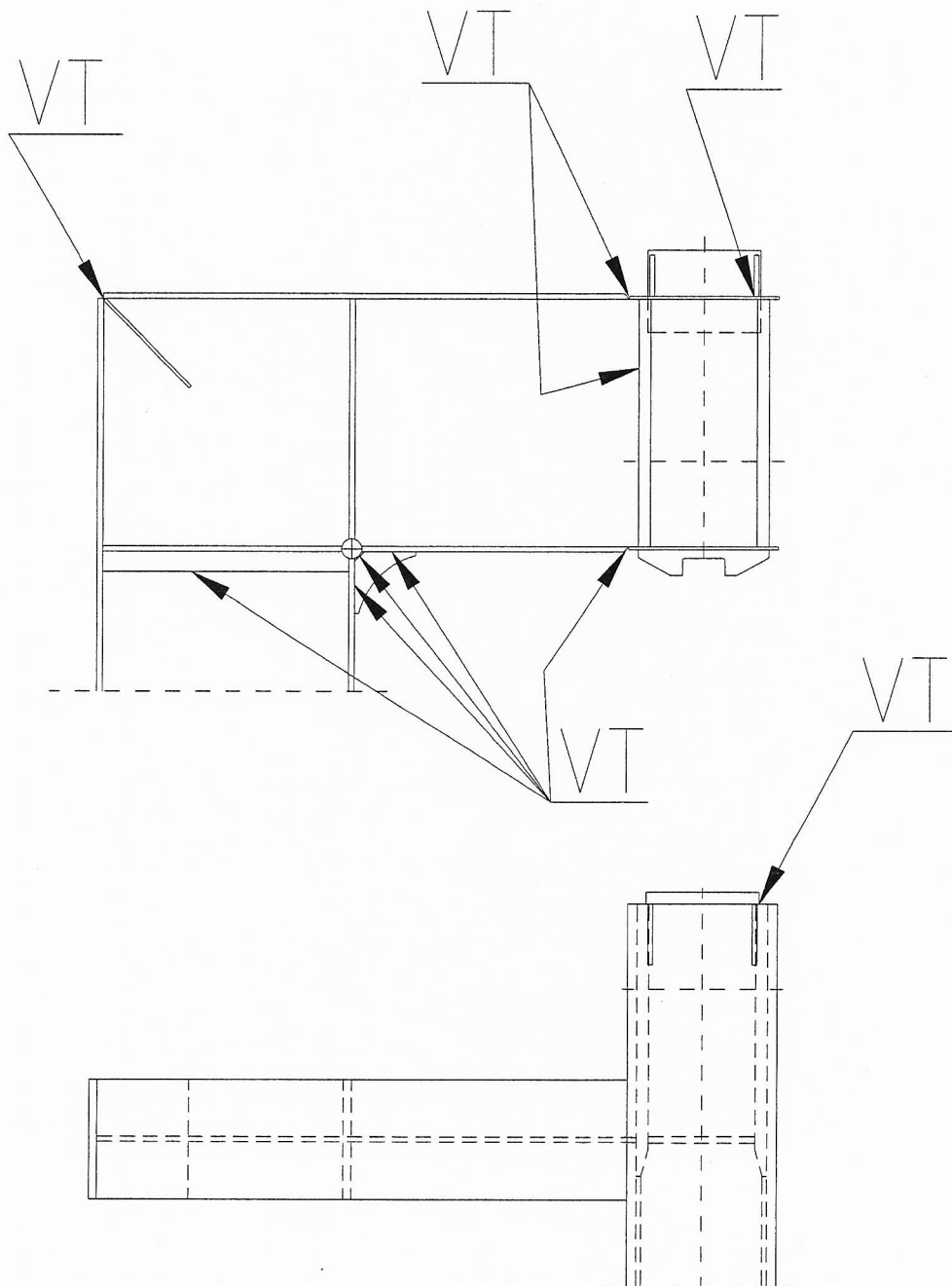
Detail 2-10 - Flange Joint



6.3 Trolley & Operator's Cab

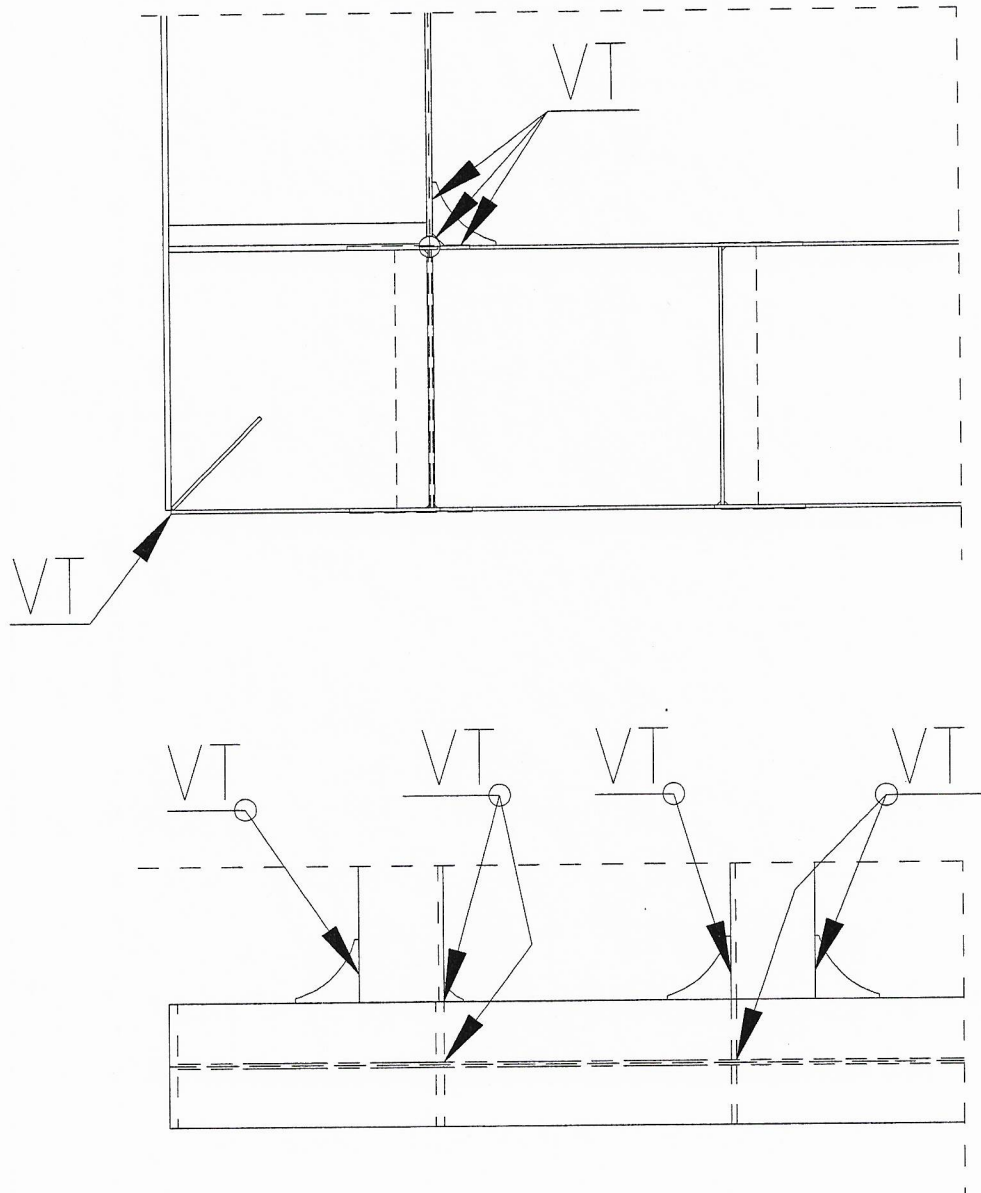


Inspection Plan - Trolley



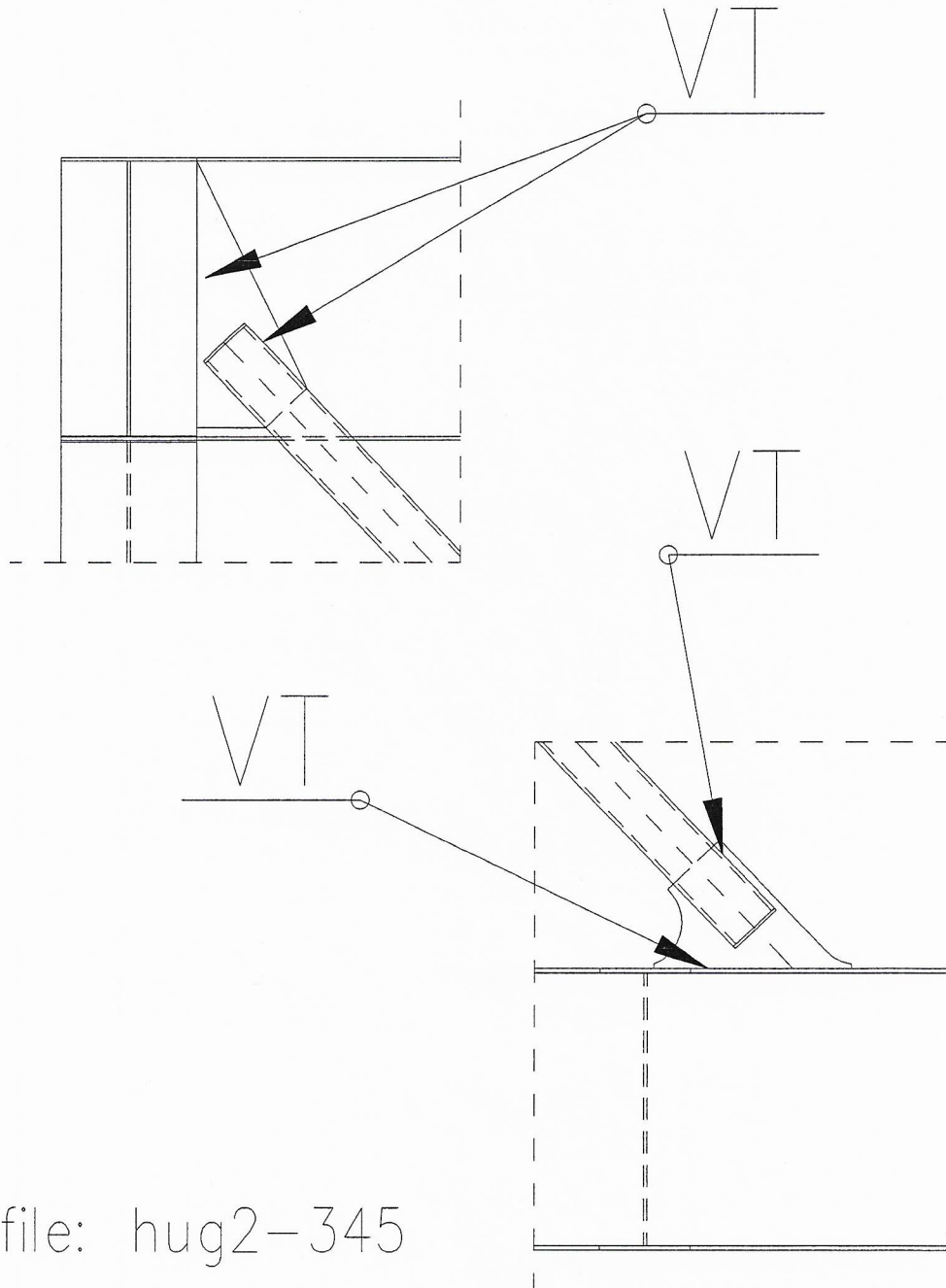
file: hug2-342

Detail 3-1 - Top of Trolley Frame Hangers



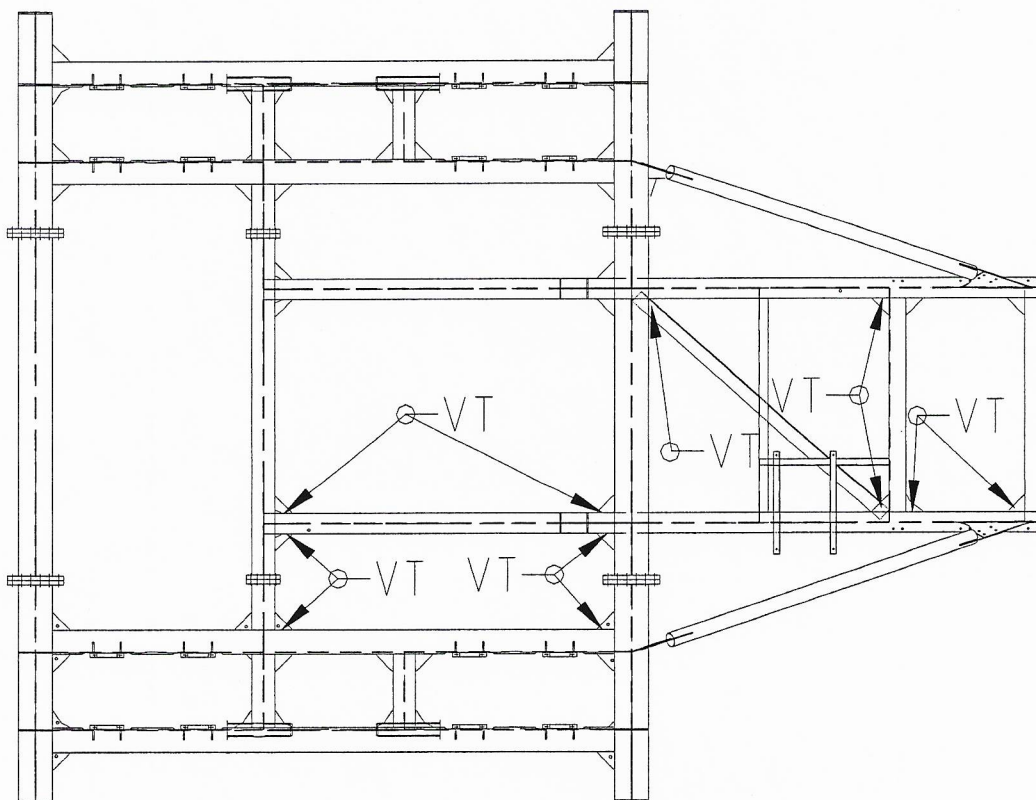
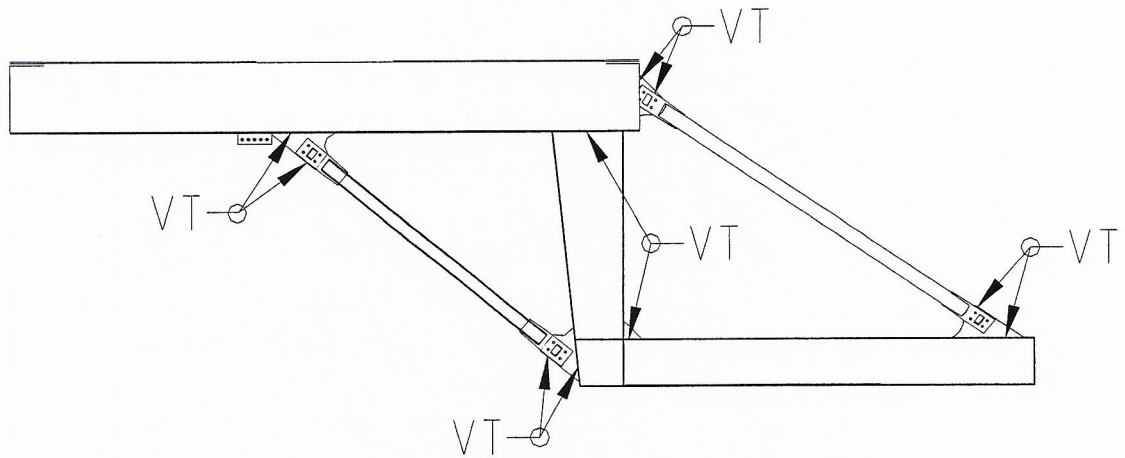
file: hug2-343

Detail 3-2 - Bottom of Trolley Frame Hangers

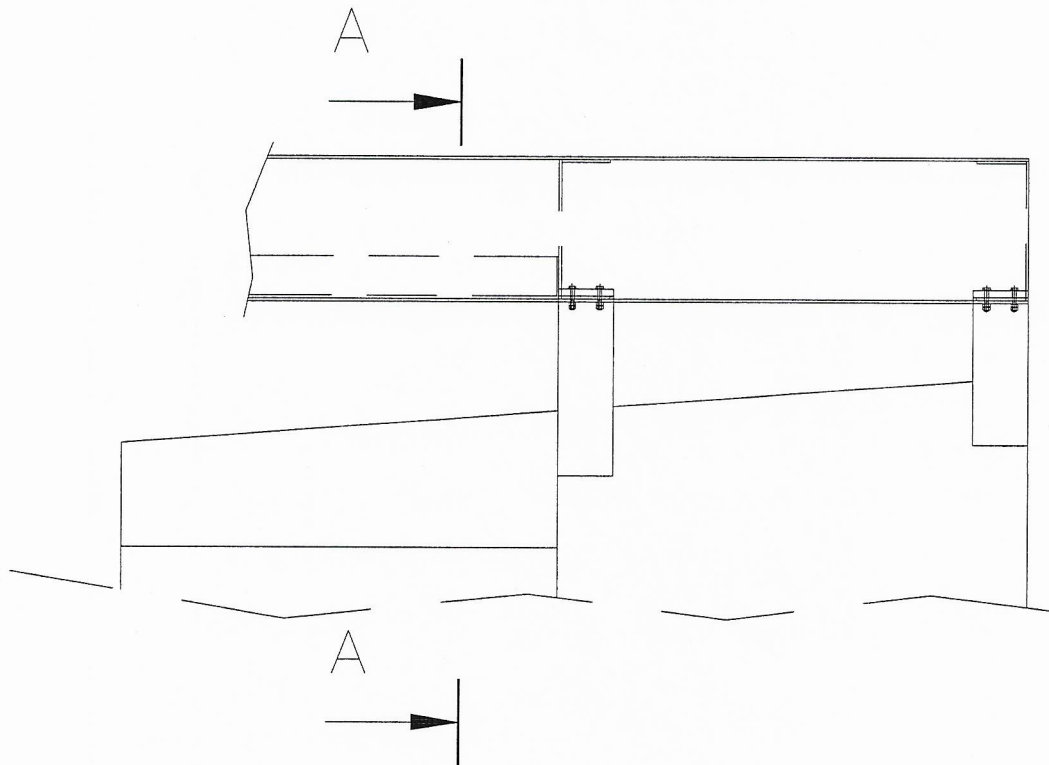


file: hug2-345

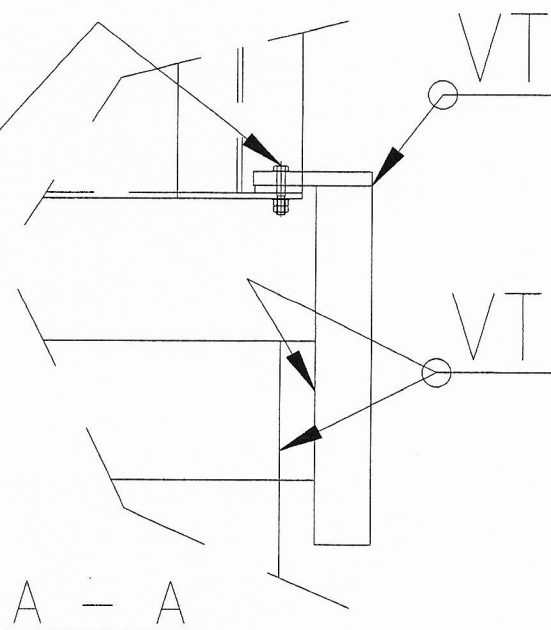
Detail 3-3 - Diagonal Bracing of Trolley Frame



Detail 3-4 - Cab Mounting Frame



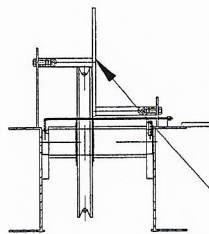
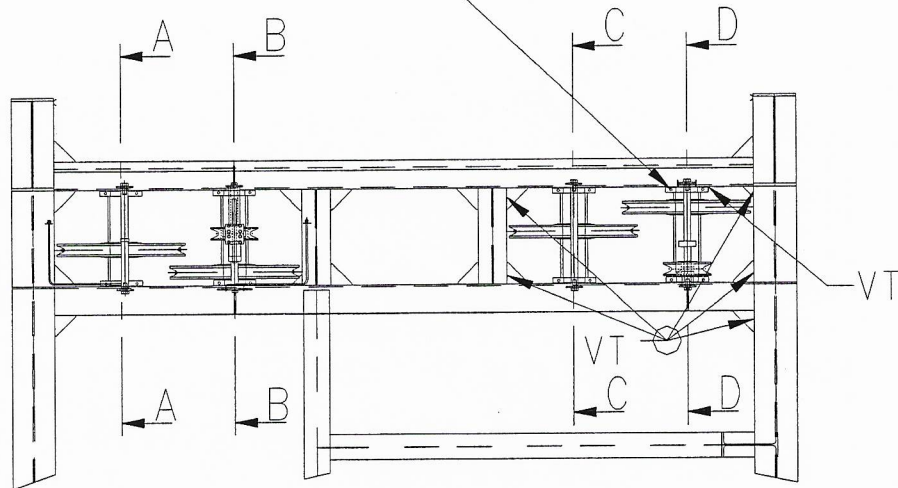
CHECK THE CONDITION OF BOLTS



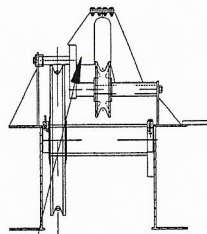
file: hug2-346

Detail 3-5 - Cab Attachment

Check the condition
of all bolts.

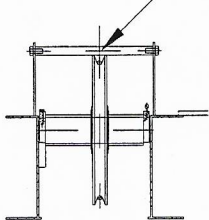


A-A

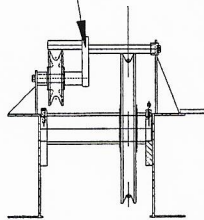


B-B

Check the condition
of all bolts and
rope guide structure



C-C



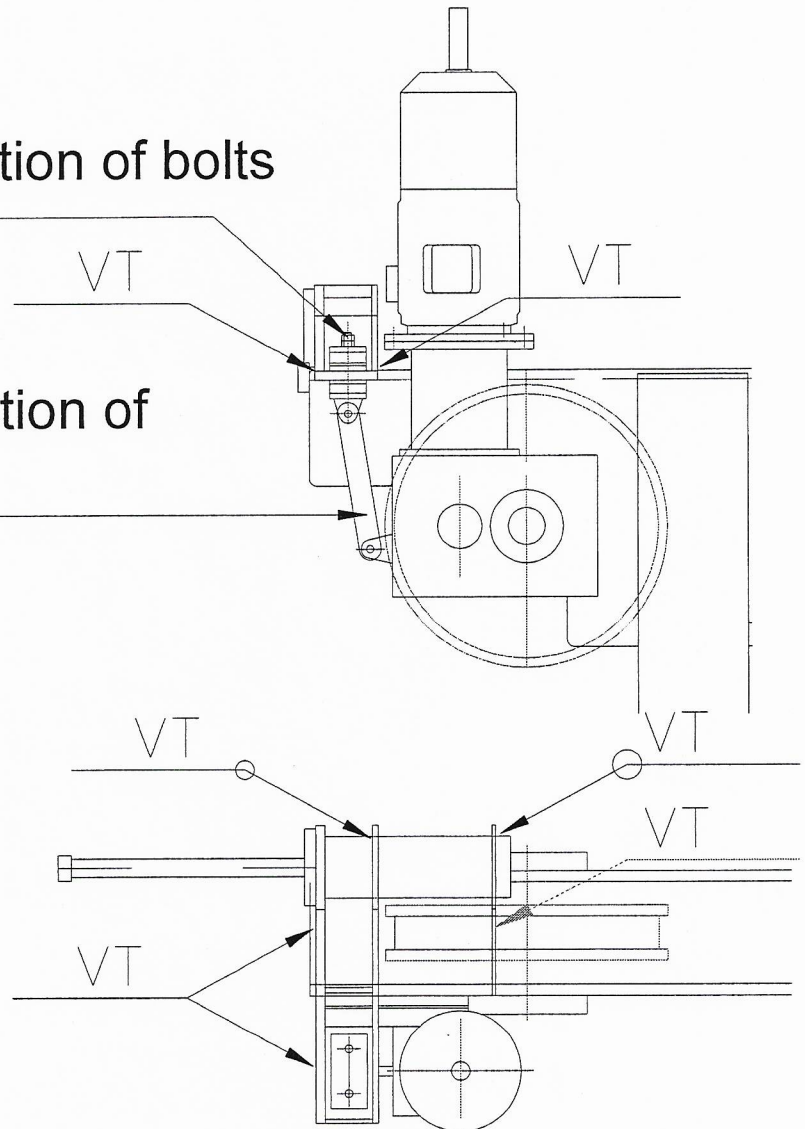
D-D

Detail 3-6 - Pulley Mountings for Main Hoist Ropes



Check the condition of bolts

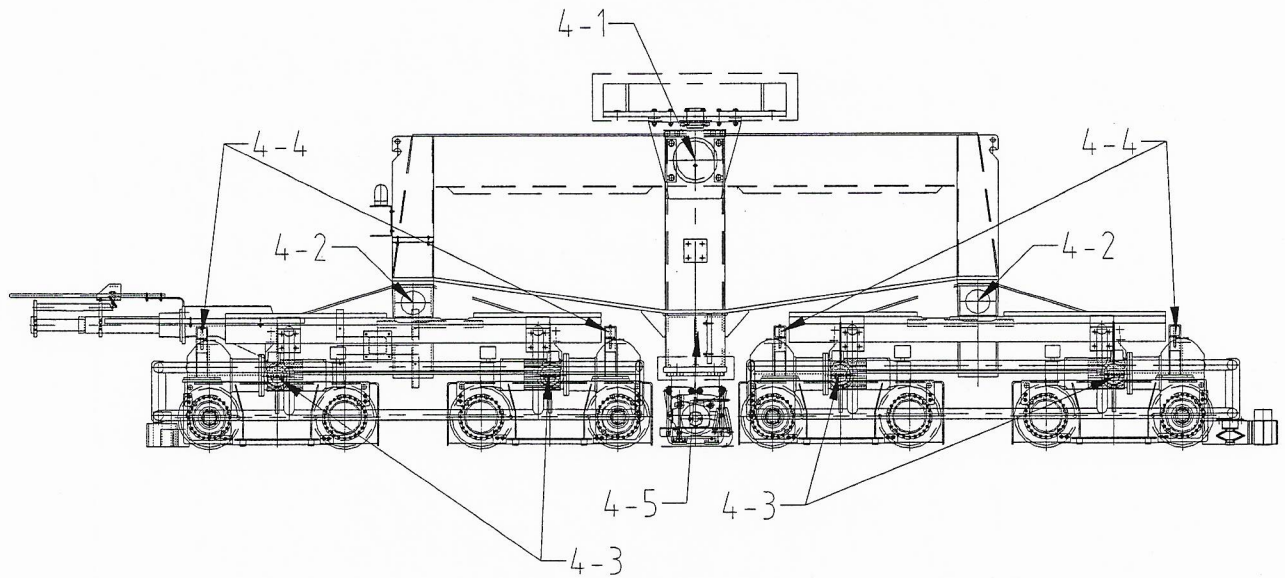
Check the condition of
torque arm



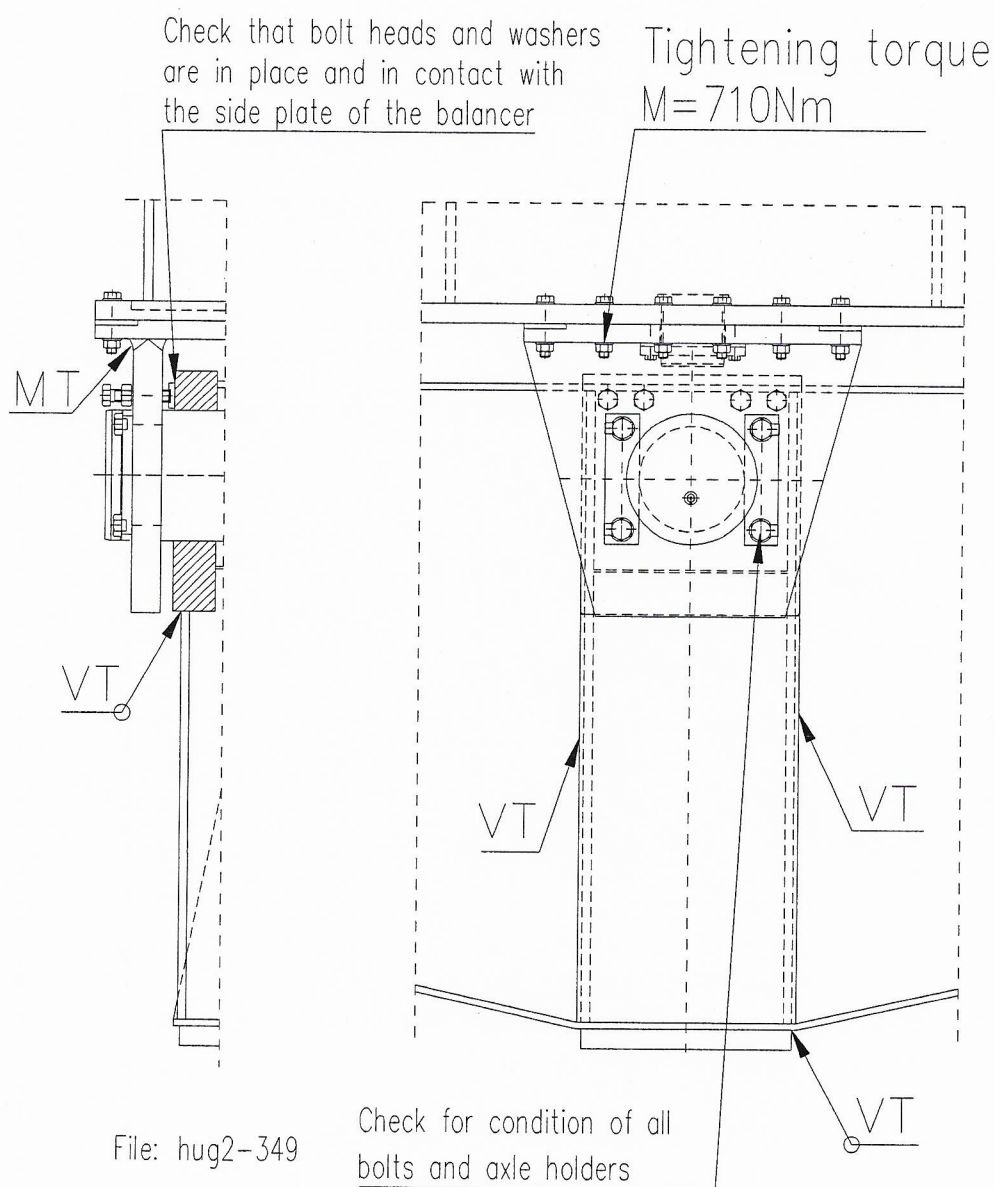
Detail 3-7 - Buffer and Traverse Drive Mountings (x4)



6.4 Bogies



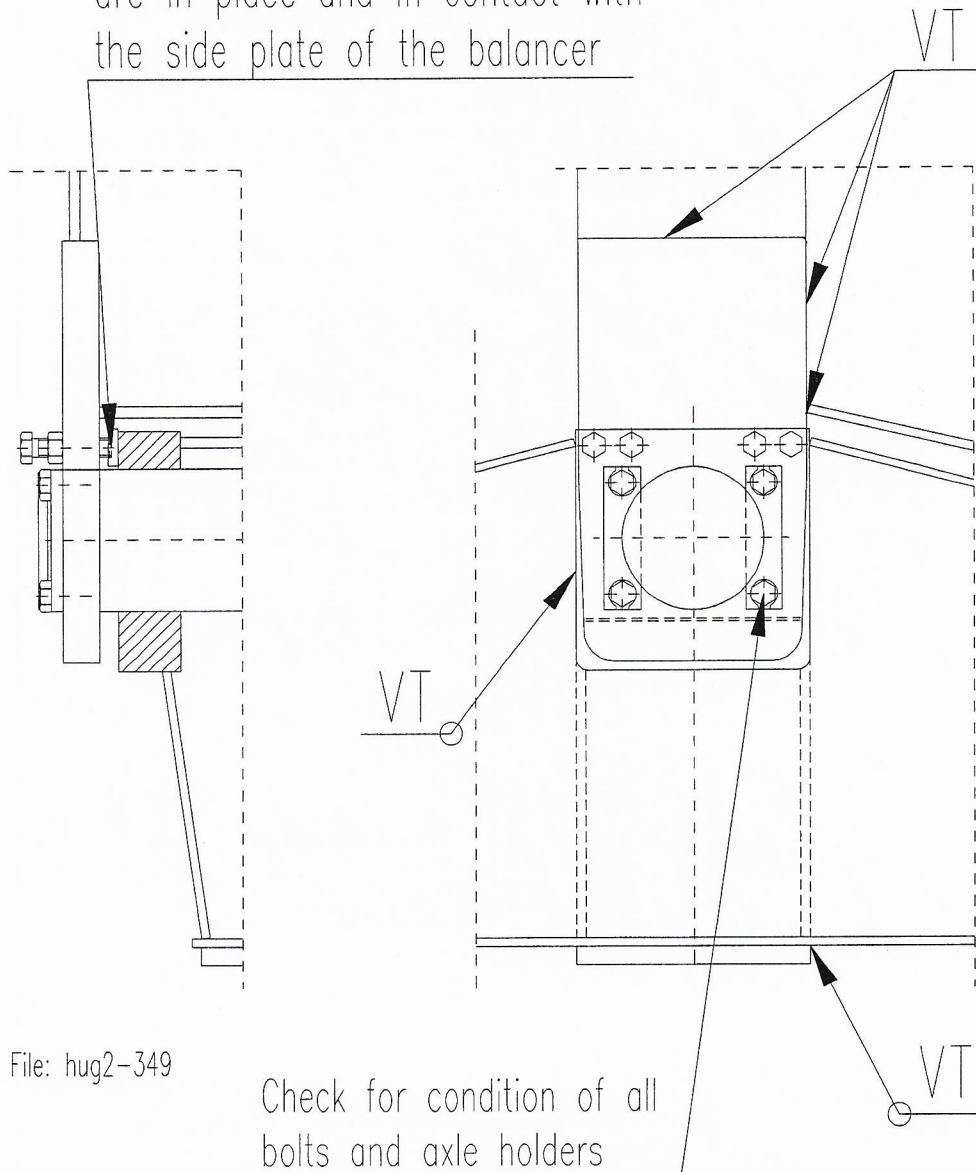
Inspection Plan - Bogies



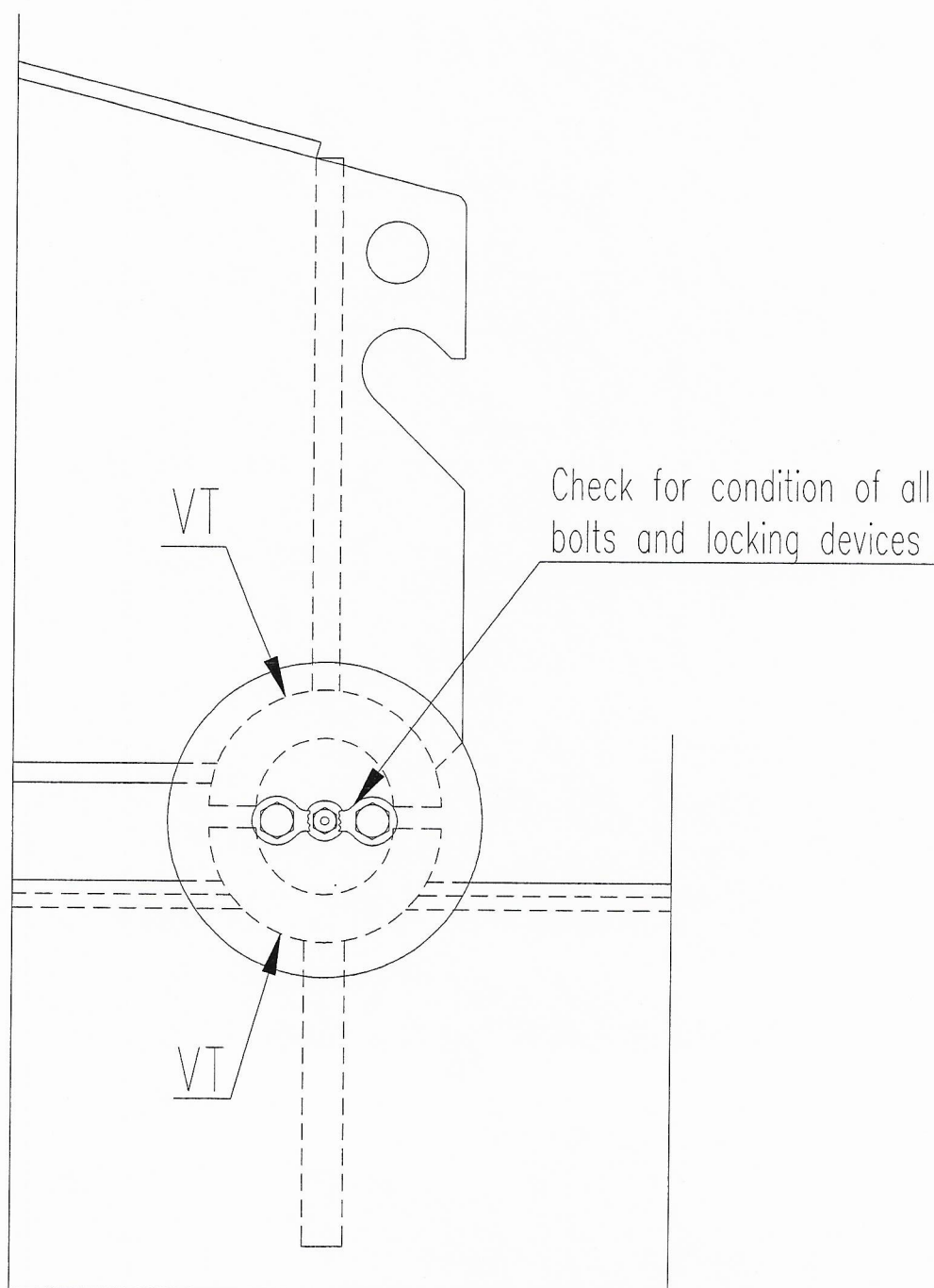
Detail 4-1 - Sill Beams to Upper Balancing Beams



Check that bolt heads and washers
are in place and in contact with
the side plate of the balancer

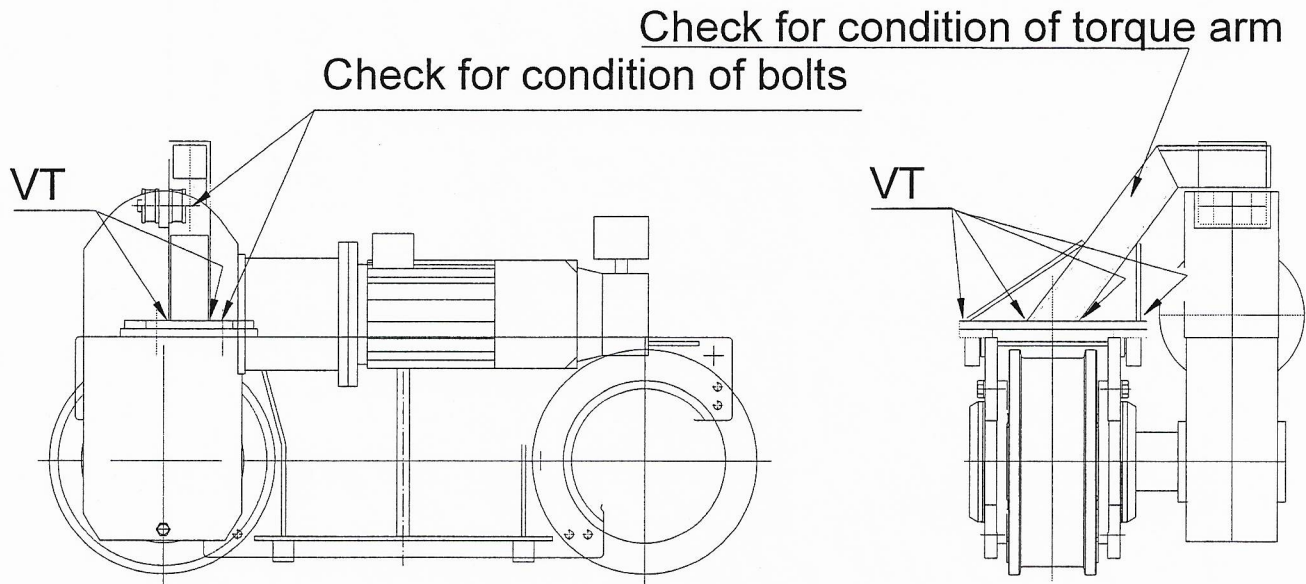


Detail 4-2 - Upper to Lower Balancing Beams

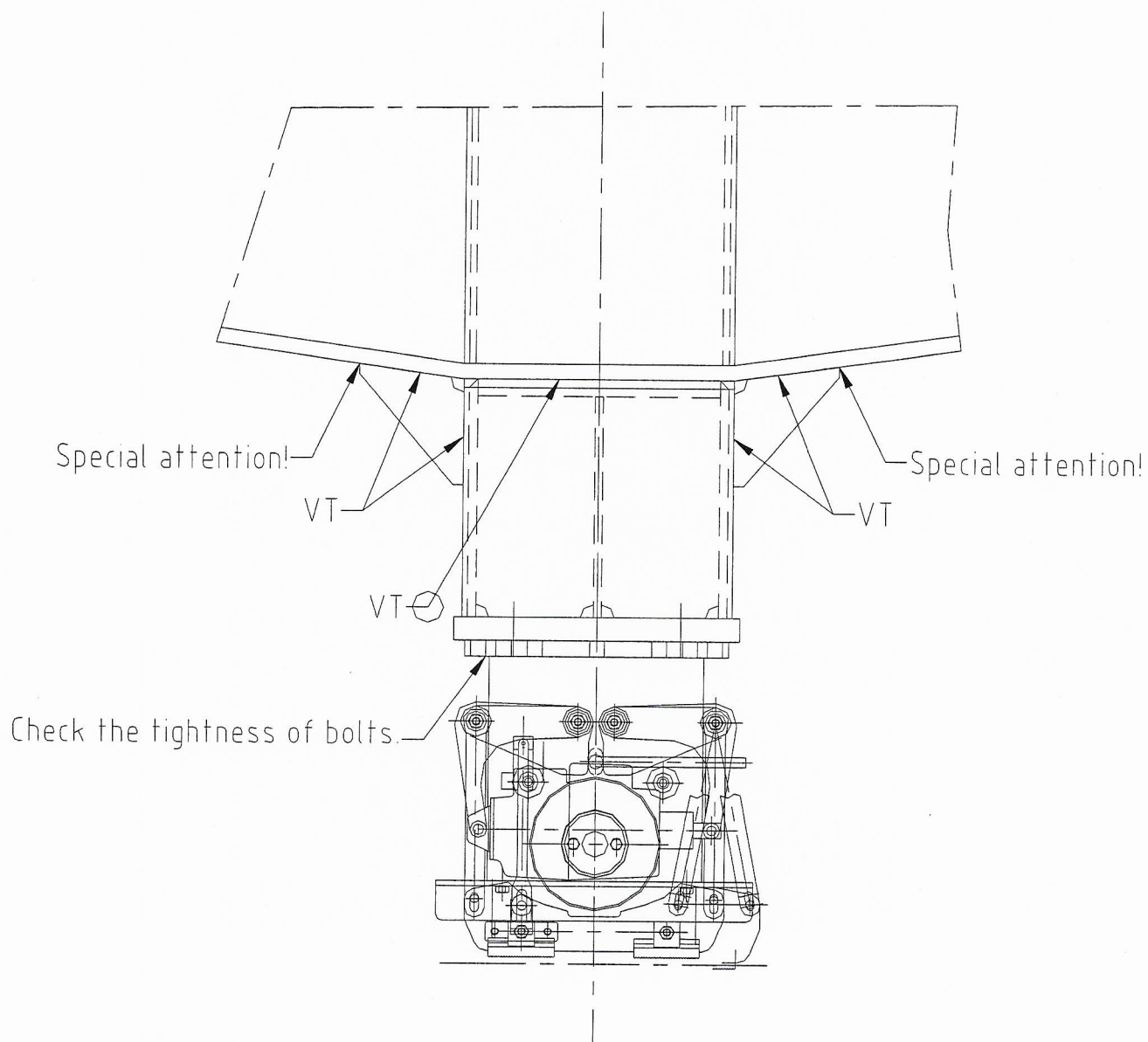


File: hug2-350

Detail 4-3 - Balancing Beams to Bogie Trucks

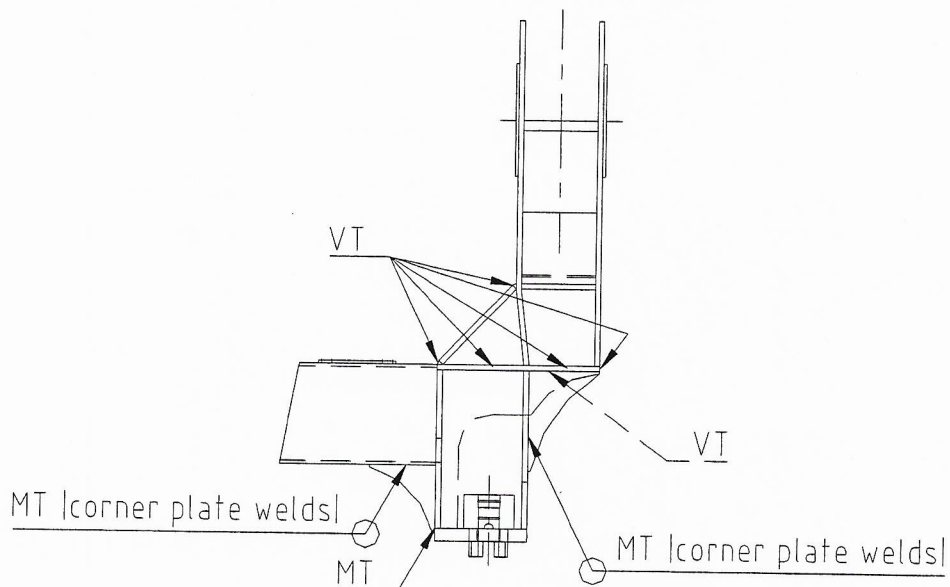
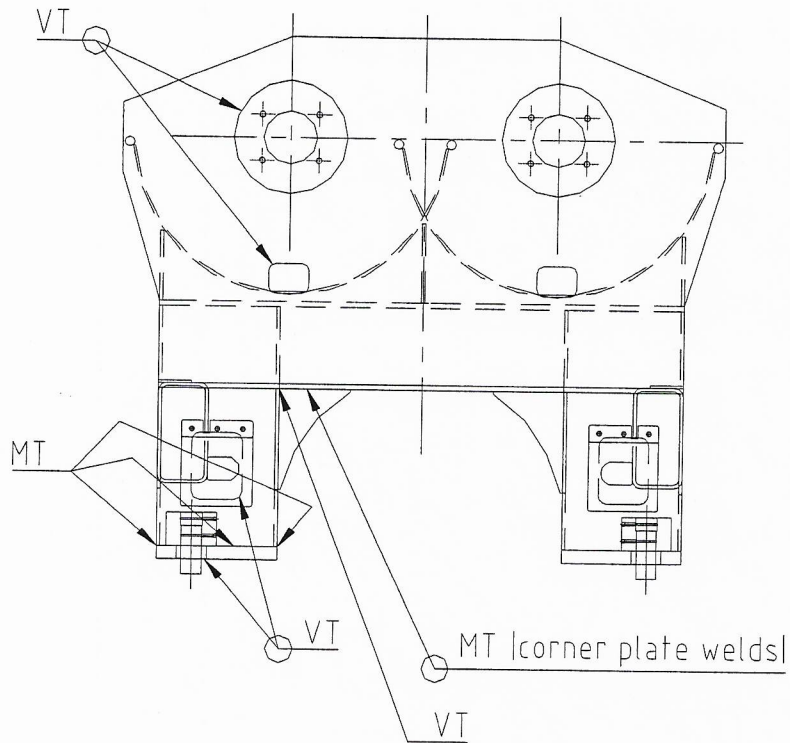


Detail 4-4 - Bogie Trucks and Gantry Travel Machinery



Detail 4-5 – Rail Brake Support

6.5 Head Block



Inspection Plan - Headblock