Millmate Roll Force Measurement
PFVL 141
User Manual
USE OF SYMBOLS

This publication includes the following symbols with information regarding safety or other important information:

- **CAUTION**
  - Caution icon indicates important information. Risk of damage to equipment, property or software.

- **DANGER**
  - Danger icon indicates a hazard which could result in personal injury or even death.

- **ELECTRICAL**
  - Electrical warning icon indicates the presence of a hazard which could result in electrical shock.

- **ESD**
  - ESD icon indicates that electrostatic discharge precautions are needed.

- **Information**
  - Information icon alerts the reader to relevant facts and conditions.

- **Tip**
  - Tip icon advise how to design your product or how to use a certain function.

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**CE-marking**

This product meets the requirements specified in the RoHS Directive 2011/65/EU, EMC Directive 2014/30/EU and the Low Voltage Directive 2014/35/EU provided the installation is carried out in accordance with the instructions given in this manual.

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1 Introduction

1.1 About this Manual

This manual describes the load cells PFVL 141V, PFVL 141C and PFVL 141R of Millmate® Roll Force Measurement System.

The purpose of this manual is to describe the general function and design of the load cells and also to be a guidance for installation, commissioning, maintenance and fault tracing.

Normally, a complete measuring system consists of two load cells, two matching units, and one control unit.

The load cells measure the separating force in the roll gap during rolling. The load cells measure force directed at right angles to the mounting surface.

The following load cells can be chosen, depending on where in the mill stand the load cells are going to be installed:

- Rectangular load cell PFVL 141V
- Circular load cell PFVL 141C
- Annular load cell PFVL 141R

The load cells are connected to the control unit via a matching unit.

The control unit converts the load cell force signals into normalized DC signals which are proportional to the roll separating force. As a result, four analog signals are generated, one signal for each load cell, one representing the sum of the load cell signals, and one representing the difference between the load cell signals.

The measured values are presented on a panel unit which is a part of the control unit.
1.2 Cyber Security Disclaimer

This product has been designed to be connected and communicate data and information via a network interface which should be connected to a secure network. It is the sole responsibility of the person or entity responsible for network administration to ensure a secure connection to the network and to take the necessary measures (such as, but not limited to, installation of firewalls, application of authentication measures, encryption of data, installation of antivirus programs, etc.) to protect the product and the network, its system and interface included, against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB is not liable for any such damages and/or losses.

1.3 Disposal and Recycling

1.3.1 Environmental Policy

ABB is committed to its environmental policy. We strive continuously to make our products environmentally more sound by applying results obtained in recyclability and life cycle analyses. Products, manufacturing process as well as logistics have been designed taking into account the environmental aspects.

Our environmental management system, certified to ISO 14001, is the tool for carrying out our environmental policy. However it is on the customer’s responsibility to ensure that local legislation is followed.
1.3.2 Recycling Electrical and Electronic Equipment, WEEE

The crossed – out wheeled bin symbol on the product(s) and / or accompanying documents means that used electrical and electronic equipment (WEEE) should not be mixed with general household waste.

If you wish to discard electrical and electronic equipment (EEE), in the European Union, please contact your dealer or supplier for further information.

Outside of the European Union, contact your local authorities or dealer and ask for the correct method of disposal.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

1.3.3 Recycling the Transport Material

ABB designs all transport material to be recyclable where practical. The recycling of the transport material depends on the material type and availability of local recycling programs.

After receiving the system into the site, the package and the transportation locking have to be removed. Recycle the transport material according to local regulations.

1.3.4 Disposal of the Product

When the product is to be disposed, it should be dismantled and the components recycled according to local regulations.

1.3.4.1 Dismantling and Recycling of the Product

Dismantle and recycle the components of the product according to local regulations.

CAUTION

Some of the components are heavy! The person who performs the dismantling of the system must have the necessary knowledge and skills to handle heavy components to avoid the risk of accidents and injury from occurring.

- Load cell: These parts are made of structural steel, which can be recycled according to local instructions. All the auxiliary equipment, such as cabling or hoses must be removed before recycling the material.
2 Technical Description

2.1 General

The Millmate® Roll Force Measurement System is designed for measuring the separation force applied in a rolling mill. Normally, the system consists of:

- two load cells
- two matching units
- one control unit in a wall or floor mounted cubicle
- cabling.

The load cells are supplied from the control unit power supply. The load cell signal is proportional to the applied force and is processed in the control unit. The load cell signals are not sensitive to electromagnetic interference due to their low source impedances and galvanic isolation from the control unit and earth connections.

Figure 2. Load cell positioning
2.2 Measurement Principle

Pressductor® technology is based on the change of the magneto-elastic properties in the material which the load cell core is made of. The load-dependent change of the magnetic properties of the material is in this way used for inducing a voltage over a secondary measurement winding in the load cell core.

The core of a load cell consists of a large number of turns. The turns are made of magneto-elastic plate wound around an inner ring. One single measuring zone will consist of the four holes in a turn plate with associated excitation and measurement signal windings.

The primary excitation winding is supplied with a special alternating current, creating a magnetic flux in the adjacent steel. As long as no load is applied to the transducer element, no net magnetic flux will occur around the secondary, signal, winding at the standard excitation. When the transducer is exposed to a force in the measurement direction, the magneto-elastic change in the steel will allow the magnetic flux to incorporate the secondary winding, inducing an AC voltage proportional to the applied force.

![Diagram of load cell core](image)

2.3 Load Cell Design

Each type of load cell is made up of a core of high-tensile steel plates bonded together.

The core is the active part which contains up to 1500 measuring zones, depending on the load cell size and type. Each measuring zone contributes to the total signal. In this way the load cell is less sensitive to variations of the force over the load cell surface, and this increases the measuring accuracy.

The secondary and primary windings are resistant to oil, moisture and dirt, therefore it is only necessary to protect them from mechanical damage. The integral circuits are encapsulated inside the load cell and are designed to give a calibrated and temperature compensated output signal.

Apart from the pressure surfaces, which are anti-corrosion treated, the load cells are painted with a two-component plastic based paint.
The load cells have removable lifting eye bolts for easy handling.

See section 2.3.1 to section 2.3.3 for calculating the nominal load for the load cells. See also Appendix A Drawings.

2.3.1 Rectangular Load Cell PFVL 141V

Calculation of the nominal load of the load cell is done by using the following equation:

Nominal Load = W x L x 0.0001 MN (W and L in mm)
2.3.2 Circular Load Cell PFVL 141C

![Circular Load Cell PFVL 141C](image)

Calculation of the nominal load of the load cell is done by using the following equation:

\[
\text{Nominal load} = \frac{D^2 \times \pi}{4} \times 0.0001 \text{ MN} \quad (D \text{ in mm})
\]
2.3.3 Annular Load Cell PFVL 141R

![Diagram of Annular Load Cell PFVL 141R]  

Figure 5. Annular Load Cell PFVL 141R

![Diagram of Section of Annular Load Cell PFVL 141R]  

Figure 6. Section of Annular Load Cell PFVL 141R

Calculation of the nominal load of the load cell is done by using the following equation:

\[
\text{Nominal load} = \left( \frac{(D3)^2 \times \pi}{4} - \frac{(D2)^2 \times \pi}{4} \right) \times 0.0001 \text{ MN} \quad (D2 \text{ and } D3 \text{ in mm})
\]

2.3.4 Technical Data for Load Cell PFVL 141V/C/R

The measuring range of PFVL 141 load cells is specified on the designation plate mounted on the load cell, in the calibration certificate and in the order forms.
Mechanical data, such as weight, width etc. and nominal load for the individual load cells are given in the order documents.

### PFVL 141 Load Cells

<table>
<thead>
<tr>
<th>Nominal Load</th>
<th>Unit</th>
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<tr>
<td>Rectangular load cell PFVL 141V</td>
<td>0.63 - 56 MN</td>
</tr>
<tr>
<td>Circular load cell PFVL 141C</td>
<td>1.6 - 60</td>
</tr>
<tr>
<td>Annular load cell PFVL 141R</td>
<td>1 - 28</td>
</tr>
</tbody>
</table>

### Overload Limit

| Max. load without permanent change of data | 300 N/mm² (MPa) |
| Max. load without permanent mechanical damage* | 700 |

### Accuracy

| Accuracy Class          | ± 0.5 (of nominal load) |
| Linearity Deviation     | ≤ ± 0.5 (of nominal load) |
| Repeatability error     | ≤ ± 0.1 (of nominal load) |
| Hysteresis              | ≤ 0.2 (of nominal load) |
| Compression             | 0.05 mm (nominal load) |

### Temperature

| Compensated Temperature Range | +20 to +80 °C |
| Zero point drift             | ≤ ± 0.01 %/K |
| Sensitivity drift            | ≤ ± 0.01 |
| Working Temperature Range    | -10 to +90 °C |
| Storage Temperature Range    | -40 to +90 °C |

* Recalibration is required after loads higher than 300% of nominal load.

### 2.3.5 Load Cell Signal Characteristics

#### Nominal load

Nominal load, $F_{\text{nom}}$, is the maximum load in the measurement direction for which the load cell is dimensioned to measure within the specified accuracy class. The load cell is calibrated up to $F_{\text{nom}}$.

#### Sensitivity

Sensitivity is defined as the difference in output values between nominal load and zero load.
Accuracy and Accuracy Class

Accuracy class is defined as the maximum deviation, and is expressed as a percentage of the sensitivity at nominal load. This includes linearity deviation, hysteresis and repeatability error.

Linearity Deviation

Linearity deviation is the maximum deviation from a straight line drawn between the output values at zero load and nominal load. Linearity deviation is related to the sensitivity.

Hysteresis

Hysteresis is the maximum difference in the output signal at the same load during a cycle from zero load to nominal load and back to zero load, related to the sensitivity at nominal load. The hysteresis of a Pressdctor transducer is proportional to the load cycle.
Repeatability error

Repeatability error is defined as the maximum deviation between repeated readings under identical conditions. It is expressed as a percentage of the sensitivity at nominal load.

Compensated temperature range

The temperature drifts of the load cell have been compensated for in certain temperature ranges. That is the temperature range within which the specified permitted temperature drifts (i.e. zero point and sensitivity drifts) of the load cell are maintained.

Working temperature range

Working temperature range is the temperature range within which the load cell can operate within a specified accuracy. The maximum permitted temperature drifts (i.e. zero point and sensitivity drifts) of the load cell are not necessarily maintained in the whole working temperature range.

Storage temperature range

Storage temperature range is the temperature range within which the load cell can be stored.

Zero point drift with temperature

Zero point drift is defined as the signal change with temperature, related to the sensitivity, when there is zero load on the load cell.

Sensitivity drift with temperature

Sensitivity drift is defined as the signal change with temperature at nominal load, related to the sensitivity, excluding the zero point drift.

Compression

Compression is the total reduction in the height of the load cell when the load is increased from zero to the nominal value.
2.4 Matching Unit

The matching unit compensates for the reactive load of the load cell and its cable. The matching unit transforms the excitation current from the control unit to the level required by the load cell. The unit is further used as a junction box for the load cell signals.

Each load cell requires one matching unit, which is interchangeable between load cells. It can be located up to 30 m away from the relevant load cell (depending on the nominal load).

Depending on which load cell is to be used, there are two matching units to choose between, PFVO 142 or PFVO 143, see table below:

<table>
<thead>
<tr>
<th>Matching unit</th>
<th>is intended for</th>
<th>Ratio</th>
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<td>All rectangular load cells PFVL 141V</td>
<td>1.95 A / 25 A</td>
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<tr>
<td></td>
<td>All circular load cells PFVL 141C</td>
<td></td>
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<td>Annular load cells PFVL 141R with nominal load &gt; 8 MN</td>
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</tr>
<tr>
<td>PFVO 143</td>
<td>Annular load cells PFVL 141R with nominal load ≤ 8 MN</td>
<td>1.95 A / 5 A</td>
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Dimensions: (H x W x D) 300 x 200 x 120 mm, IP65, weight 8kg.
2.5 Electrical Circuit

The electrical circuit of the load cell is shown in the diagram below.

![Electrical Circuit Diagram](image)

The load cell is supplied with an alternating current of 5 A or 25 A, 1638 Hz, depending on the type of load cell. The secondary signal is calibrated for the correct sensitivity with a voltage divider R1 - R2. Temperature compensation is provided by thermistors included in the voltage divider.
All resistances on the secondary side are relatively low. The output impedance is typically 10 - 25 ohm, which helps to suppress electromagnetic interference.
3 Installation

3.1 Transport and Handling

Although the Millmate Roll Force Meter is a precision measuring system which is intended for severe operating conditions in a harsh industrial environment, it must be handled with care while unpacking, in storage and during installation.

**CAUTION**
Do not place the load cells or load cell packages close to high current conductors and make sure that no magnetic lifting devices are used when relocating the load cells or when mounting them in their installations.

3.2 Package and Delivery

To prevent delays in the installation work, make sure that the equipment is complete at delivery. Check against the order receipt or dispatch note and report any uncertainties to ABB immediately.

3.3 Installation

3.3.1 General

To achieve high accuracy, reliability and long-term stability, the load cells must be installed in accordance to the instructions below. It is important that the pressure surfaces of the load cell package are protected from damage and corrosion.

**CAUTION**
Never weld, drill or make any other alteration to the load cell. Do not use the load cell as a working surface or table in any way.

**CAUTION**
When mounting, be careful so that the pressure surfaces don’t become grimy.
3.3.2 Installation Drawings

The load cell package, consisting of load cell and pressure plates, is usually designed specifically for the roll stand in question, and a special installation drawing is prepared. This drawing, which must be followed during installation work, normally provides all the information needed.

The following design demands must be considered together with the installation drawings:

- The load cell package must be compact and form an integral part of the mill stand.
- The load cell package must be designed and mounted in such a way that force shunting does not occur.
- The roll force must be well distributed over the load cell pressure surface.
- The load cell must be well protected against lateral forces.
- The clearance between the load cell and other parts must be correct.
- Avoid sharp corners and edges close to the cabling.

![Figure 14. Preferred tolerances for the pressure surfaces in a rectangular load cell package](image1)

![Figure 15. Preferred tolerances for the pressure surfaces in a circular load cell package](image2)
3.3.3 Dimensions of Pressure Plates

The pressure plate material should have an elastic limit (i.e. Yield Strength) of at least 500 N/mm² or 500 MPa, and be uniformly hardened to a hardness of at least 350 Brinell.

The dimensions for the pressure plates must conform to the installation constraints and the type and size of the load cell chosen.

For annular load cells, it is possible to exclude the lower pressure plate located between the mill nut and the load cell, when the available space is insufficient.

3.3.4 Preparation before Installation

Prepare for the installation thoroughly by checking that the necessary documents and material are available, as follows:

- This manual, installation drawings, and inspection and test records.
- Standard tools, torque wrench and test instrument for measurement of resistance and insulation (measuring range 0.01 Ω - 100 Ω and 1 MΩ max. 500 V).
- Rust protection, if additional protection is to be given to machined surfaces. Choose e.g. TECTYL 511 (Valvoline) or FERRYL (401) or equivalent.
- Locking fluid (medium strength), e.g. Loctite 242 or equivalent, to lock bolts.
- Solvent, e.g. ligroin or isopropanol to clean the load pressure surfaces. Other solvents may be used for other surfaces.
- Load cells, pressure plates, etc.

3.3.5 Cleaning

Clean all pressure surfaces in the load cell package thoroughly with recommended solvent.

3.3.6 Anti-Corrosion Protection

All surfaces of the load cell package must be given anti-corrosion treatment before assembly. Spray or brush on a thin coating of the recommended anti-corrosion compound.
3.3.7 Installation of Rectangular Load Cells PFVL 141V

3.3.7.1 General

A load cell package for installation of a rectangular load cell is shown in the figure below:

When installing rectangular load cells the following points must be considered:

- The pressure surfaces in the load cell package must be pressed against each other and they should be pre-loaded, to prevent water and dirt entering between the pressure plates and the load cell.
  
  Pre-loading of the load cell package can be accomplished with disc springs or pre-loaded membranes. See the installation drawing for the actual case.

- Bolts holding the load cell package together must be secured to prevent them from working themselves loose. This can be done with different methods, for example with locking fluid, tab washers, locking wire or similar techniques.
  
  Tighten the bolts to the prescribed torque and lock them in the manner specified on the installation drawing.

3.3.7.2 Mounting

The load cell and its connector can be delivered with or without the connector mounted.

The separate connector shall be mounted outside the load cell package. The load cell cables are pulled out through a hole in the load cell package and connected to the separate connector. Note that the connections to the connector must be encapsulated at the time of installation.

An extended connector can also be installed at the load cell.
Assembly of a rectangular load cell with fitted connector:

1. Assemble the parts in the load cell package according to the installation drawing.
2. Make sure that there is sufficient clearance between the load cell and the mill stand. See the installation drawing.
3. Make sure that the parts are fixed according to the installation drawing.
4. Make sure, whenever applicable, that the pre-loading of the load cell package is correct.
5. Make sure that all bolts are tightened to the prescribed torque specified in the installation drawing and are locked using an appropriate locking method.
6. Attach the cable connector to the load cell connector. Tighten the sleeve nut by hand.
7. Place the load cell package in position on the mill stand. Make sure that the connector is not damaged during the assembly.

Assembly of a rectangular load cell with separate connector:

1. Unscrew the protection cap from the load cell and pull out enough wire to extend through the hole in the load cell package plus a bit more for convenient fitting of the connector.
2. Make sure that there is sufficient clearance between the load cell and the mill stand. See the installation drawing.
3. Assemble the parts in the load cell package according to the installation drawing.
4. Make sure that the parts are fixed according to the installation drawing.
5. Make sure, whenever applicable, that the pre-loading of the load cell package is correct.
6. Make sure that all bolts are tightened to the prescribed torque specified in the installation drawing and are locked using an appropriate locking method.
7. Run the wires through the hole in the load cell package.
8. Make sure that the gasket which must be fitted between the connector and the load cell package is in position on the connector.
9. Solder the wires to the pins of the connector. The figure below shows the reference letters of the load cell male connector pins, viewed from the soldering side. Start with pin B and D.
10. Check that each wire is soldered to the correct pin by measuring the resistance between A-C and B-D. See the inspection and test records for correct values.
11. Check that the connections are correct by measuring the insulation level with an insulation tester. Measure the insulation between ground and pin A, between ground and pin B and between pin A and pin B. In all of these cases the insulation must be greater than 1 MΩ at 500V.

**CAUTION**
Before using the insulation tester, connect pins A and C together to protect the load cell trim components from damage.

12. Encapsulate the connector pin with the potting compound.
13. Position the wires in the cavity, making sure that no wires are jammed. Ensure that the gasket is correctly positioned and fasten the connector.
14. Check the insulation again.
15. Attach the cable connector to the load cell connector. Tighten the sleeve nut by hand.
16. Place the load cell package in position on the mill stand. Make sure that the connector is not damaged during the assembly.

![View of connector pins](image)

**3.3.8 Installation of Circular Load Cells PFVL 141C**

**3.3.8.1 General**

A load cell package for installation of a circular load cell is shown in the figure below:

![Diagram of load cell package](image)

When installing circular load cells the following points must be considered:

- The pressure surfaces in the load cell package must be pressed against each other and they should be pre-loaded, to prevent water and dirt entering between the pressure plates and the load cell.

  Pre-loading of the load cell package can be accomplished with disc springs or pre-loaded membranes. See the installation drawing.
• Bolts holding the load cell package together must be secured to prevent them from working loose. This can be done with e.g. locking fluid, tab washers, or locking wire.

Tighten the bolts to the prescribed torque and lock them in the manner specified on the installation drawing.

3.3.8.2 Anti-Rotation Arrangement

The parts in the load cell package must be locked to ensure that they do not rotate relative to each other. The upper pressure plate can be locked to the cylindrical sleeve by using, e.g. keys, locking pins and bolts. The figure below shows an arrangement with keys.

CAUTION

Beware of the risk of force shunting via the rotation locks, if the keys are too large, or if the locks have been wrongly assembled. Bolts screwed into two diagonally positioned holes of the four holes provided for eye bolts in the load cell are used to lock the load cell relative to the lower pressure plate. There must be two corresponding holes in the pressure plate to accept the heads of the bolts.

Note that the threaded length of the bolts must not exceed 16 mm.

Check that all rotation-locking devices are correctly installed in accordance with the installation drawing.

3.3.8.3 Mounting

The load cell is either delivered with the connector mounted at the load cell or with a connector for separate mounting.

The separate connector is mounted outside the load cell package, i.e. the load cell cables are pulled out through a hole in the cylindrical sleeve and connected to the separate connector. Note that the connections to the connector must be potted at the time of installation.
An extended connector can also be installed at the load cell.

Figure 20. Connector alternatives for circular load cells

Assembly of a circular load cell with fitted connector:

1. Assemble the parts in the load cell package.
2. Make sure that there is sufficient clearance between the load cell and the cylindrical sleeve. See the figure above and the installation drawing.
3. Make sure that the parts are fixed and locked against rotation according to the installation drawing.
4. Make sure, whenever applicable, that the pre-loading of the load cell package is correct.
5. Make sure that all bolts are tightened to the prescribed torque specified in the installation drawing and are locked using an appropriate locking method.
6. Attach the cable connector to the load cell connector. Tighten the sleeve nut by hand.
7. Place the load cell package in position on the mill stand. Make sure that the connector is not damaged during the assembly.

Assembly of a circular load cell with separate connector:

1. Unscrew the protection cap from the load cell and pull out enough wire to extend through the hole in the load cell package plus a bit more for a convenient fitting of the connector.
2. Make sure that there is sufficient clearance between the load cell and the cylindrical sleeve. See the figure above and the installation drawing.
3. Assemble the parts in the load cell package.
4. Make sure that the parts are fixed and locked against rotation according to the installation drawing.
5. Make sure, whenever applicable, that the pre-loading of the load cell package is correct.
6. Make sure that all bolts are tightened to the prescribed torque specified in the installation drawing and are locked using an appropriate locking method.
7. Run the wires through the hole in the cylindrical sleeve.
8. Position the cylindrical sleeve carefully, without damaging the wires.
9. Make sure that the gasket which must be fitted between the connector and the cylindrical sleeve is in position on the connector.
10. Solder the wires to the pins of the connector. The figure below shows the reference letters of the load cell male connector pins, viewed from the soldering side. Start with pin B and D.
11. Check that each wire is soldered to the correct pin by measuring the resistance between A-C and B-D. See the inspection and test records for correct values.
12. Check that the connections are correct by measuring the insulation level with an insulation tester. Measure the insulation between ground and pin A, between ground and pin B and between pin A and pin B. In all of these cases the insulation must be greater than 1 MΩ at 500V.

**CAUTION**
Before using the insulation tester, connect pins A and C together to protect the load cell trim components from damage.

13. Encapsulate the connector pin with the potting compound.
14. Position the wires in the cavity, making sure that no wires are jammed. Ensure that the gasket is correctly positioned and fasten the connector.
15. Check the insulation again.
16. Attach the cable connector to the load cell connector. Tighten the sleeve nut by hand.
17. Place the load cell package in position on the mill stand. Make sure that the connector is not damaged during the assembly.

Figure 21. View of connector pins

### 3.3.9 Installation of Annular Load Cells PFVL 141R

#### 3.3.9.1 General

A load cell package for installation of a circular load cell is shown in the figure below:

When installing an annular load cell the following points must be considered:

- The pressure surfaces in the load cell package must be pressed against each other and they should be pre-loaded, to prevent water and dirt entering between the pressure plates and the load cell.

Pre-loading of the load cell package can be accomplished with disc springs. See the installation drawing.
Bolts holding the load cell package together must be secured to prevent them from working loose. This can be done with different methods, for example with locking fluid, tab washers, locking wire or similar techniques. Tighten the bolts to the prescribed torque and lock them in the manner specified on the installation drawing.

3.3.9.2 Anti-Rotation Arrangement

The parts in the load cell package must be locked to ensure that they do not rotate relative to each other. The load cell and the pressure plates must be fixed relative to the mill nut, with screws and dowel pins.

Check that all rotation-locking devices are correctly installed in accordance to the installation drawing.

3.3.9.3 Mounting

The load cell is delivered with the connection cable connected to the load cell, see figure below. The cable must be routed through the lower pressure plate and the mill nut, and further on to the matching unit.
3.3.10 Installation of Matching Units PFVO 142/143

The matching units shall be placed as close to the load cells as possible, and well protected against mechanical damage and heat radiation.

The matching units must be well grounded. It is not enough to ground them through the mounting lugs. A separate cable, connected to a grounding point, is needed.

CAUTION
If the matching unit is grounded at the load cell installation, the ground connection (terminal 4 in matching unit) must not be connected to ground at the control unit.

All components in the matching unit are mounted on one plate. This plate can be removed and mounted in a locally supplied box, if required. Any changes will require consideration of local electrical safety regulations.
All components in the matching unit are CE-approved for safety reasons.

3.4 Connections

Make sure that all connections are performed correctly.

After connecting the load cell cable, check the connections at the terminals in the matching and control units and make sure that there is no poor connection at any terminal in the matching unit or anywhere else in the primary circuit. If there would be any problem with the electrical connections at the terminals in the named units, the control/operator unit would indicate the error message “too high input impedance” when the power supply is switched on. Find out about the location of the problem and correct it before proceeding. Make sure that the power supply is switched on properly and run a self test afterwards.

3.5 Testing Procedure

Check the increase of the output signal from the load cells when the lower back up roll is mounted in the mill stand. If this increase corresponds to the weight of the back up roll then it is a sign of good correlation between the output signal and the load acting on the load cell.

A lower back up roll assembly, having a weight of 40 tons, would for example correspond to a signal increase of approximately 0.20MN per side when the back up roll is mounted in the mill stand.

For more available tests see the manual for the actual control unit connected to the load cells.
The procedure for commissioning the load cells is simple, provided that the load cells and the cables have been properly installed. This procedure is carried out in parallel with the commissioning of the control unit. However, this procedure is described in a separate manual.

Check the following:

- That the load cells have been correctly installed and aligned
- That all screws have been tightened to the correct torque
- That all cables are correctly installed and connected
- That all connectors are plugged in
- That resistance and zero signal of the load cells are correct according to the inspection and test record
- That the insulation of the load cells is higher than 1 MΩ at 500 V
- That all terminals in matching unit have been retightened, especially 11 and 12.
5 Inspection and Maintenance

The Millmate® Roll Force Measurement System is designed for continuous operation in harsh environmental conditions, which reduces the need for maintenance and service to a minimum. A system which has been designed, dimensioned and installed correctly can work for very long periods of time with only periodic maintenance.

Periodic inspection should be performed on the components that are subjected to vibration. These are mainly the matching units and the cables. Inspection of the integrity of the force path parts, such as rocker, pressure plates as well as the underlying support structure should preferably be carried out every 6th month, or at least once every year.

To avoid any unnecessary, unplanned shutdowns, it is recommended that a complete load cell package is kept as spare.

The system components are factory calibrated and can be replaced directly with another component of the same type, geometry and load rating etc.

5.1 Inspection and Maintenance of Load Cell Package

5.1.1 General

Maintenance of the load cell package involves measures to prevent corrosion on the mating surfaces of both the load cells and the pressure plates, and to keep the installation free from dirt and particles. Poor maintenance can cause poor load distribution, resulting in poor measurement performance and eventually partial overloads.

- Any damage indicating design, dimensioning or installation faults must be corrected and documented with reference, for future maintenance.
- When dismantling for maintenance, the mating surfaces of the load cell and the pressure plates must be inspected. The surface flatness and uniform thickness should be measured and compared to the installation requirements.
- In order to check if an overload has mechanically damaged the load cells, a test program should be executed. See the control unit manual, chapter “Fault tracing”.
- After any installation, or re-installation, the first check should be done after six to twelve months. The following maintenance interval are decided on the basis of the experience then gained:
  - If the surfaces of the load cell package is near fault-free, this indicates that the design is correctly dimensioned. In this case a longer maintenance interval can be set.
  - If the surfaces are damaged, the cause must be determined and the damage corrected. A new check should be done within 6 months.
5.1.2 Preparation before Maintenance

Prepare for the maintenance by checking that the necessary documents and material are available:

- Installation drawings, inspection and test records
- Standard tools, torque wrench and test instruments for measurement of resistance and insulation (measuring range 0.01 Ω - 100 Ω and 1 MΩ max. 500 V)
- A straight-edge and feeler gauge for inspection of flatness
- Micrometer for inspection of uniform thickness
- Solvents, e.g. white spirit or isopropanol, to clean the load pressure surfaces.
- Rust protection, if additional protection is to be given to machined surfaces. For example TECTYL 511 (Valvoline) or FERRYL (104)
- Locking fluid (medium strength), for example Loctite 242, to lock fixing screws
- Load cells, pressure plates, etc.

5.2 Inspection of the Mechanical Installation

5.2.1 Rectangular and Circular Load Cells

The cable and connector of the load cell must be handled carefully. Any damage will undoubtedly lead to malfunctions. It is important to check that the cable is not damaged or trapped in any way during dismantling and assembly.

Information

If the load cell has a separate connector, i.e. if the connector is mounted on the casing around the load cell package, the wires must be cut when dismantling. Cut the wires as close to the connector as possible so that they are not shortened more than necessary.

Recommended workflow:

1. Switch off the excitation of the load cell.
2. Carefully lift the load cell package, i.e. load cell and pressure plates, away from the mill stand. Take the package to a workshop or some other suitable place for dismantling.
3. Thoroughly clean all parts and take particular care of the pressure surfaces.
4. Check that the connection cable is undamaged.

5. Inspect any rotation locks in the load cell package. Look for signs of incorrect clearance and damage. Those signs should be documented and reported.
   - Too little clearance can result in uneven force distribution, which can cause damage to the cell.
   - Too much clearance can result in the pressure plates and the load cell have moved relative to each other, which also can cause damage to the load cell.

6. Check the load cells and the pressure plates for flatness and uniform thickness. The values must be within the permitted tolerance limits, see Tolerance Requirements and Check Lists for Installations. If not, the surfaces must be re-ground.

Flatness is measured with straight-edge and feeler gauges. On site, use a felt-tip pen to draw a grid of measurement points on the surfaces to be checked. Make the measurements with the straight-edge positioned both straight and diagonally over the measurement points. Document the findings for further reference.

Figure 24. Flatness measurement

- For smaller local deviations in the flatness of the surface, the largest diameter of any surface indentations or holes must be less than 10 mm.
- The total area covered by indentations must not exceed 5% of the total pressure surface.
- Raised areas on the surface are completely unacceptable.

Uniform thickness can be measured with a micrometer or standing vertically in a coordinate machine, using about 10 mm distance between the measurement points. Measure and document the values.

Figure 25. Uniform thickness measurement

Check the following for rectangular load cells:
- Parallelism / flatness of the upper pressure plate.
- Parallelism / flatness of the lower pressure plate.
- Flatness of the mill stand / sledge.
Check the following for circular load cells:

- Flatness of the bearing.
- Parallelism / flatness of the upper pressure plate.
- Parallelism / flatness of the lower pressure plate.
- Flatness of the bearing housing.

5.2.2 Annular Load Cells

Recommended workflow:

1. Disconnect the connection cable from the matching unit. Then carefully dismantle the load cell package and the mill nut from the mill stand. Bring the package to a workshop or some other suitable place for dismantling.
2. Thoroughly clean all parts and take particular care of the pressure surfaces.
3. Check that the connection cable is undamaged.
4. Inspect all rotation locks in the load cell package. Look for every sign of incorrect clearance. Report all such signs.
   - Too little clearance can result in uneven force distribution, which can cause damage to the load cells.
   - Too much clearance can result in movement of the pressure plates and the load cell relative to each other, which also can cause damage to the load cells or associated cables.
5. Check that all the pressure surfaces are within recommended surface tolerances. If not, the surfaces must be re-ground.

Information

The connection cable may be stuck due to dirt and grease in the mill nut hole.

Check the following for annular load cells:

- Flatness of the mill stand.
- Parallelism / flatness of the upper pressure plate.
- Parallelism of the load cell.
- Parallelism / flatness of the lower pressure plate.
- Flatness of the mill nut.

Flatness is measured with straight-edge and feeler gauges. Use a felt-tip pen to draw a grid of measurement points on the surfaces to be checked. Make the measurements with the straight-edge positioned both straight and diagonally over the measurement points. Note the values in a report.
5.3 Inspection of the Electrical Installation

Inspection of the electrical installation is carried out by visual inspection of the cabling as well as checking the terminals inside the junction box, or the matching unit and the cabinet / enclosure.

Matching units are often exposed to vibrations, heat and cooling liquids. Points to check are:

- Screw terminals, especially terminals 11 and 12 can be damaged by overheating if they have not been properly tightened.
- The 1 μF capacitor, C1 in PFVO 102/142 can be checked with a capacitance meter or by measuring the voltage across it during operation. The voltage should be 190 V AC. The capacitor should be replaced if the capacitance is lower than 0.85 μF or if the voltage is higher than 223 V AC. A replacement capacitor has to be of industrial grade, designed for continuous operation.
- The 3 μF capacitors, C2 in PFVO 102/142 and C1-C3 in PFVO 201/143, are less critical. They work at lower load and rarely fail.
5.4 Electrical Maintenance and Recommendations

Periodic maintenance should be carried out for the different electrical equipment of the Millmate Roll Force system. A summary of recommended maintenance interval for these equipment is given in table below.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Action</th>
<th>3 Months</th>
<th>6 Months</th>
<th>1 Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosures and Cabi-</td>
<td>Cleaning</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nets</td>
<td>Checking cables</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operator Unit</td>
<td>Cleaning</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cabling</td>
<td>Visual inspection</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junction Box</td>
<td>Check terminals</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matching Units</td>
<td>Check terminals</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.5 Other Units

5.5.1 Control Unit

Apart from checking the terminals and cable connections, the control unit does not require any additional periodic maintenance.

A fault in the control unit usually causes intermittent loss of a function. It is unusual for the control unit to cause stability problems. Faults in connected units may affect the operation of the control unit.

5.5.2 Excitation Unit

Apart from checking the cable connections, the excitation unit does not require any periodic maintenance.

5.5.3 Matching Unit

The only periodic maintenance required for the matching unit PFVO 142/143 is checking the screw terminals to make sure that they are properly tightened.

5.5.4 Operator Unit

The operator unit contains no parts requiring maintenance by the user. Apart from cleaning the enclosure and the keyboard, no routine maintenance is required for the operator unit.
5.5.5 Cabinets

Check that:

- All screw terminals are well tightened
- All units are securely fastened
- No cables or conductors are damaged

5.5.6 System Test

Maintenance of the Roll Force System and associated electronics should also include a system test.

The Millmate® Controller 400 contains a system test which checks the measuring object and its connected units. The system test cannot be started when measurement is in progress. It must also be started manually. This is because any ongoing measurement is interrupted when the cabling and load cells are checked.

The system test consists of 64 part tests. These can be run one at a time or in sequence.

See MC400 User Manual for a complete description of the system test and the system error list. See also the control unit user manual for further details on system tests.

5.6 Interchangeability

5.6.1 Load Cells

The load cells are interchangeable with load cells of the same type and measuring range. A system test must be performed and new reference values must be stored.

The load cells are factory calibrated and can be replaced directly with another load cell of the same type, geometry and load rating. After load cell replacement, adjust the zero setting and storage of reference data in control unit. See separate manual for MC400 control unit.

5.6.2 Matching Units

Matching units are interchangeable with units of the same type. PFVO 102 is also interchangeable with PFVO 142, and PFVO 201 is interchangeable with PFVO 143.

Phase compensation has to be performed according to MC400 User Manual.

5.6.3 Millmate Controller 400

The control unit MC 400 is interchangeable with control units of the same type. Replacement can also be done according to the table below. All settings must be reentered, a system test must be performed and new reference values must be stored.
The table below shows the different types of control units and how they are replaceable with each other.

<table>
<thead>
<tr>
<th>Installed control unit, MC 400 type</th>
<th>Replacement control unit, MC 400 type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PFXA 401</td>
</tr>
<tr>
<td>PFXA 401</td>
<td>X</td>
</tr>
<tr>
<td>PFXA 401F</td>
<td></td>
</tr>
<tr>
<td>PFXA 401S</td>
<td></td>
</tr>
<tr>
<td>PFXA 401SF</td>
<td></td>
</tr>
</tbody>
</table>

5.7 Spare Parts

It is recommended that the following spare parts are kept in stock:

- load cell of correct size and type
- connection cable between the load cell and the matching unit
- matching unit of correct type
- load cell connector
- set for potting
- pressure plates

Table 1 Spare Parts

<table>
<thead>
<tr>
<th>Spare part</th>
<th>Reference</th>
<th>Order number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load cell</td>
<td>PFVL 141V / 141C / 141R</td>
<td>See order document.</td>
</tr>
<tr>
<td>Matching unit for annular load cells up to 8 MN</td>
<td>PPVO 143</td>
<td>3BSE023150R0001</td>
</tr>
<tr>
<td>Matching unit for the other load cells</td>
<td>PPVO 142</td>
<td>3BSE023732R0001</td>
</tr>
<tr>
<td>Connector</td>
<td>See order document.</td>
<td>3BSE024398R0001 3BSE024397</td>
</tr>
<tr>
<td>Cable between load cell and matching unit</td>
<td>See order document.</td>
<td>3BSE032981</td>
</tr>
</tbody>
</table>
6 Fault Tracing and Troubleshooting

6.1 Introduction

The measuring system can be divided into four parts:

- Mechanical installation
- Load cell
- Matching units and cabling
- Control unit (see MC 400 manual)

There are a number of typical fault symptoms, for example:

- No signal
- Intermittent signal
- Changed zero signal
- Unstable zero point
- Incorrect sensitivity
- Start up problem
- Intermittent loss of function

It is important to be thoroughly familiar with the measuring system as described in the manuals, before starting any fault tracing.

6.2 Necessary Equipment

The following equipment is required to perform fault tracing and repairs:

- Cable diagram for the actual installation
- Inspection and test records
- Servicing tools (screwdriver, pliers, etc.)
- Instruments for resistance and insulation measurements

6.2.1 Measuring Insulation Resistances

Normally voltage values of 500V or 1000V are used and the resistance to the current flow is expressed in units of kΩ or MΩ. The device used for introducing the voltage and measuring the insulation resistance is called the “Insulation Tester” or the “Mega-Ohm tester” or “Megger”). The procedure of measuring and testing the insulation resistance is therefore sometimes also referred to as “megging”.

Five different resistance values can be measured at the wire terminals of a Roll Force load cell:

- Resistance: Primary circuit
- Resistance: Secondary circuit
- Insulation resistance: Primary to Ground
- Insulation resistance: Secondary to Ground
- Insulation resistance: Primary to Secondary

Insulation resistances in Roll Force load cells are high at room temperature at calibration. Values larger than 500MΩ are common.

When measuring the insulation resistance between secondary and ground, the results can vary depending on the actual temperature or surface moisture condition of the parts involved. This is due to change of dielectric constant of the wire insulators (wire protections) and epoxy adhesive to the calibration circuit. To avoid these changes in results, always measure the resistances under as similar conditions as possible. The terminals shall always be dry and held at sufficient long distance from each other when measuring the insulation resistance between wire terminals and/or ground.

- The terminals shall always be dry and held at sufficient long distance from each other when measuring the insulation resistance between wire terminals and/or ground.
- These changes in insulation resistances will not affect the load cell signal as long as the insulation resistance is larger than 10kΩ. Insulation resistance below 10kΩ can affect the load cell signal and load cell performance under certain environmental conditions.

### Table 2: Causes of low insulation resistance (≤ 10kΩ)

<table>
<thead>
<tr>
<th>Test point A</th>
<th>Test point B</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Ground</td>
<td>Defective or damaged insulation cover of the primary wire</td>
</tr>
<tr>
<td>Primary</td>
<td>Secondary</td>
<td>Defective or damaged insulation cover of both the primary and secondary wires</td>
</tr>
<tr>
<td>Secondary</td>
<td>Ground</td>
<td>Damaged connector or damaged insulation cover of secondary wires</td>
</tr>
</tbody>
</table>

Damaged insulation covers of wires or damaged calibration circuit can be caused by either mechanical deformation, damage of load cell cores, or similar, or by a chemical impact.

### 6.3 Fault Symptoms and Actions

Millmate Controller 400 has a continuous monitoring function for the control unit function and the load cell excitation circuit. Fault messages can be read and acknowledged from the control unit service menu.

The control unit contains a system test which checks the system and its connected units. The system test must not be started when measurement is in progress. It has to be started manually. This is because the measurement is interrupted when cabling and load cells are checked.

See MC 400 User Manual for a complete description of the system test, the system error list and suggested measures for eliminating the possible errors. See the user manual for the MC 400 control unit for more information.

### 6.3.1 No Signal

Perform the "Major System Test" if the signal is missing.
6.3.2 Intermittent Signal

Any poor electrical connection in the matching units may cause intermittent faults. Both sensitivity and zero point might vary. Check all screw terminals. Do not use pins crimped to the connecting wires, as these often can work themselves loose after a while.

Jammed cables subjected to small movements can cause intermittent faults. The cable between the matching unit and the load cell is the most exposed part. Incorrect installation, such as screens grounded at more than one end, might cause an unstable zero point. Check that the connections (if any) at the load cell is mounted correctly and tightened.

Fault symptoms that appear for a single load cell is often caused by poor connection to affected load cell. If a fault is indicated for both load cells, the probable cause can be addressed to the control unit, its connections, or excitation current.

Some malfunctions may be due to placing the load cell cabling too close to existing cables in the mill, which will cause interference. Cables are subject to mechanical wear, and should be checked regularly. The matching unit should also be checked, especially if it is subject to vibration.

6.3.3 Changed Zero Signal

The data of a Pressductor load cell changes in steps, usually caused by an event in the mill. Excessive overloading results in a permanent shifting of the zero point.
Start by performing the "Major system test".

Measure the resistance and insulation in both the primary and secondary circuits. If no deviations are detected, check if the mill stand has been subjected to overload and if the load cell has been overloaded. If the load cell has been overloaded, send it back to the supplier for checking, recalibration and any necessary repairs.

Overload can be caused by poorly machined mounting surfaces or dirt deposits between load cell and pressure plates.

Fault Tracing of the Load Cell Primary Circuit
The resistance of the load cell primary windings is very low. The load cell and cabling can be checked from the matching unit:

**Information**
The transformer in the matching unit is connected to ground. Therefore, disconnect the wires from terminals 11 and 12 before measuring the insulation.

1. Switch off the control unit and pull out connector X4 on the excitation unit PFVI 401
2. Disconnect the load cell wires from terminal 11 and 12. The primary circuit is then completely free.
3. Measure the resistance between the disconnected wires to the load cell. Normal value is 0.1 - 0.4 Ω.
4. Measure the insulation of the primary circuit between wire from 11 and ground. The insulation must be greater than 10 kΩ.
5. If the fault is located in the load cell, it should be sent to ABB for inspection and necessary repairs.

**Fault Tracing of the Load Cell Secondary Circuit**
The insulation and resistance of the load cell secondary circuits can be checked from the control unit. See user manual for the MC 400 control unit. A more accurate check can be done by measuring directly at the terminals of the matching unit:

**CAUTION**
Short-circuit the secondary winding at the terminal blocks to prevent the load cell trim resistors from being destroyed.

1. Switch off the control unit and pull out the connectors X5 and X15 on PFXA 401. The secondary circuit is then completely free.
2. Measure the load cell resistance between terminal 13 and 14 in matching unit. Normal value is 10 - 25 Ω. See the inspection and test record and compare with the calibration value.
3. Measure the insulation of the secondary circuit between terminal 13 and ground. The insulation must be greater than 10 kΩ not to affect the measurement accuracy.
4. Measure the insulation between the primary and secondary circuits (between terminal 11 and 13).
5. If the insulation value is unsatisfactory, this check should be repeated at the load cell contact (if available).
6. If the fault can be located to the load cell, it should be sent to the supplier for checking and any necessary repairs.

### 6.3.4 Unstable Zero Point Signal
Mechanical wear or dirt deposits causes uneven mounting surfaces. An uneven mounting surface causes bending or twisting of the load cell and results in an unstable zero point. See figures for pressure surfaces requirements.

If a fault correlates to something else in the process, such as temperature, or can be linked to a particular operation, it is usually caused by some shortcoming in the mechanical installation.

### 6.3.5 Incorrect Sensitivity
With incorrect sensitivity, either the sensitivity of both load cells or of one single load cell has been changed.
Incorrect sensitivity on both load cells can be caused by a fault in the control unit. Perform the “Major System Test”.

Incorrect sensitivity on a single load cell can be caused by force shunting, a mechanical fault, or a fault in the load cell secondary unit. Check resistance and insulation of the load cell secondary circuit.

In case of mechanical fault:

1. Check if friction has occurred in and around the load cell assembly. Friction is caused by dirt, mechanical wear or too little clearance. Presence of friction is shown as increased hysteresis at the mill modules set up. For example: A reduced, or too low height of the pressure plates will cause a concentration of the load to the central part of the load cell core, causing measurement errors and partial overload.

2. Check if the pressure plates have the correct measurement. A reduced height is usually caused by mechanical wear or machining. A reduced height of the pressure plates can cause the indicated force to be lower than the actual force, and the load cycle hysteresis increases.

6.3.6 Start Up Problem

If the measuring system acts unexpectedly during the load cell excitation start up, check that the mains supply is stable enough.

6.3.7 Intermittent Loss of Function

Faults in the control unit can cause the intermittent loss of a function. Poor contact at the terminals can cause intermittent faults. It is unusual for the control unit to cause stability problems. Faults in connected units may affect the operation of the control unit. See separate manual for the control unit for more information.
Drawings

Appendix A Drawings
A.1  Circuit Diagram PFVO 142

1) C2 connects if extra phase compensation is needed.
A.2 Circuit Diagram PFVO 143

1) C3 is to be connected in series with L1 and C2 if extra phase compensation is needed
A.3 Dimension Drawing PFVO 142/143

<table>
<thead>
<tr>
<th>REV</th>
<th>DESCRIPTION</th>
<th>DATE</th>
<th>DEPT./INIT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Document kind och språk rev.</td>
<td>2003-01-07</td>
<td>ATC/PM/FvFa</td>
</tr>
</tbody>
</table>

Dimensions:
- Pr 22.5 (2x)
- Cable gland Pr 22.5 (2x) (3x) for cable D=10.5-13.5
- DIN-Locking
- 3 mm pin
- Ø14
- R4

Dimensions in millimeters:
- 250
- 300
- 36
- 19
- 14
- 25
- 26
- 13
- 8.5

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Document number: 3BSE023151

3BSE025344R0101 en Rev A
A.4 Dimension Drawing: Standard PFVL 141V

Rectangular load cells are available with the following dimensions:

- B = 70 - 610 in steps of 30
- L = 120 - 900 in steps of 30
- L = 960 - 1320 in steps of 60

Thickness tolerance:
- T
- D1 = 600
- 600 = D1 = 800
- D1 > 800

Connection cables, see sep. dimension print

On request holes for eyebolts can be made with thread 3/8"UNC.
A.5 Dimension Drawing: Standard PFVL 141C

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Connection cables, see sep. dimension print

On request holes for eyebolts can be made with thread 3/8"UNC resp. 1/2"UNC

Rated load MN

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<td>60</td>
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Thickness tolerance T

D1<=300  0.1
300<D1<=400  0.15
D1>400  0.2

ABB AB

ABB AB

Document number: 56936225-A

Sheet: 1

Product family: 662555 Valskraft
Product type designation: PFVL141
Product Information: PFVL141 C

Project or order number:

Version label: 0.0

Modify date: 2009-03-03 08:22:23
A.9  
Circuit Diagram: Junction Box PFXC 141

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### Circuit Diagram

![Circuit Diagram Image]

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**Appendix A Drawings**
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