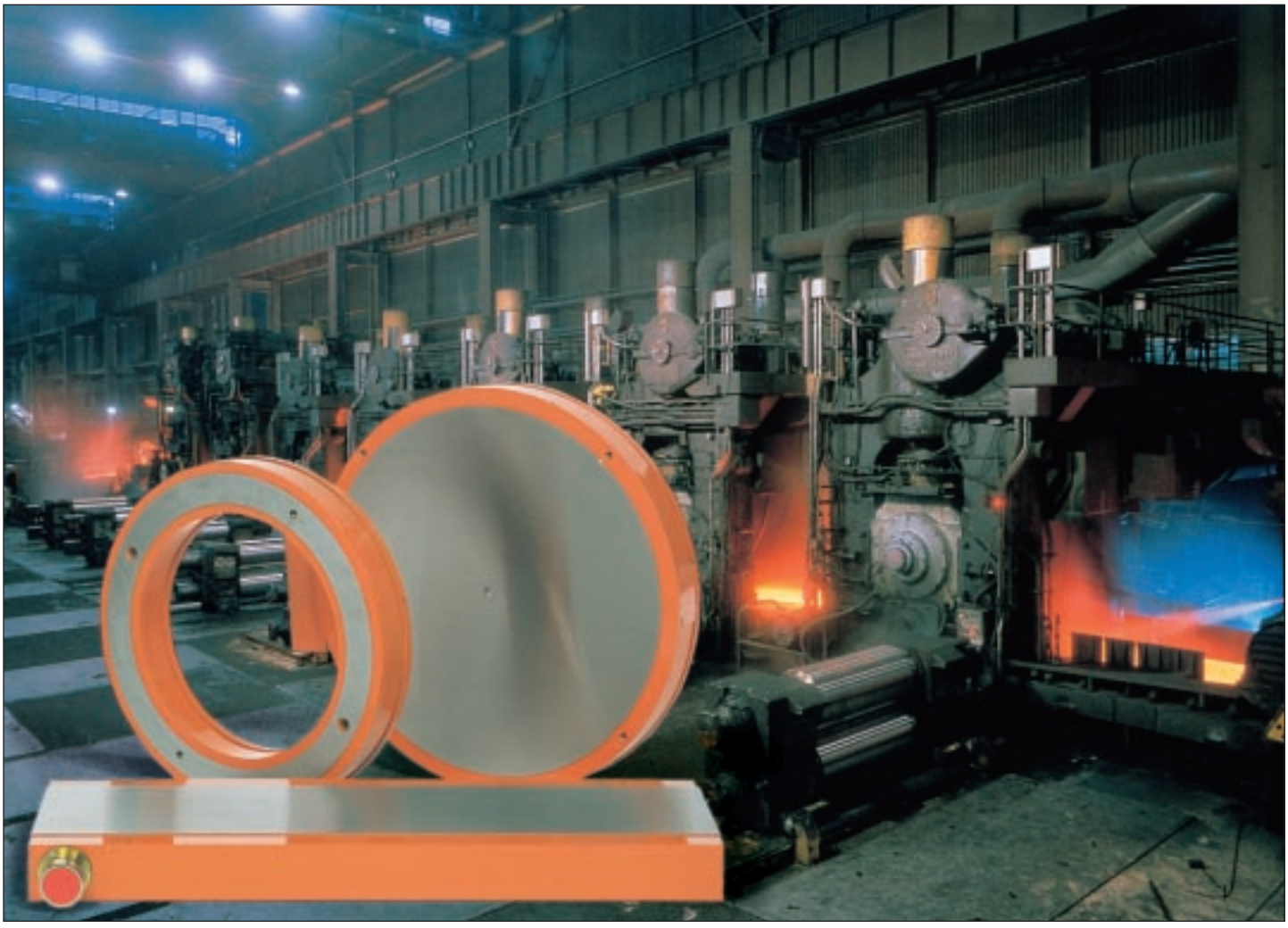


Stainless load cells for roll force measurement in hot and cold rolling mills

General System Description

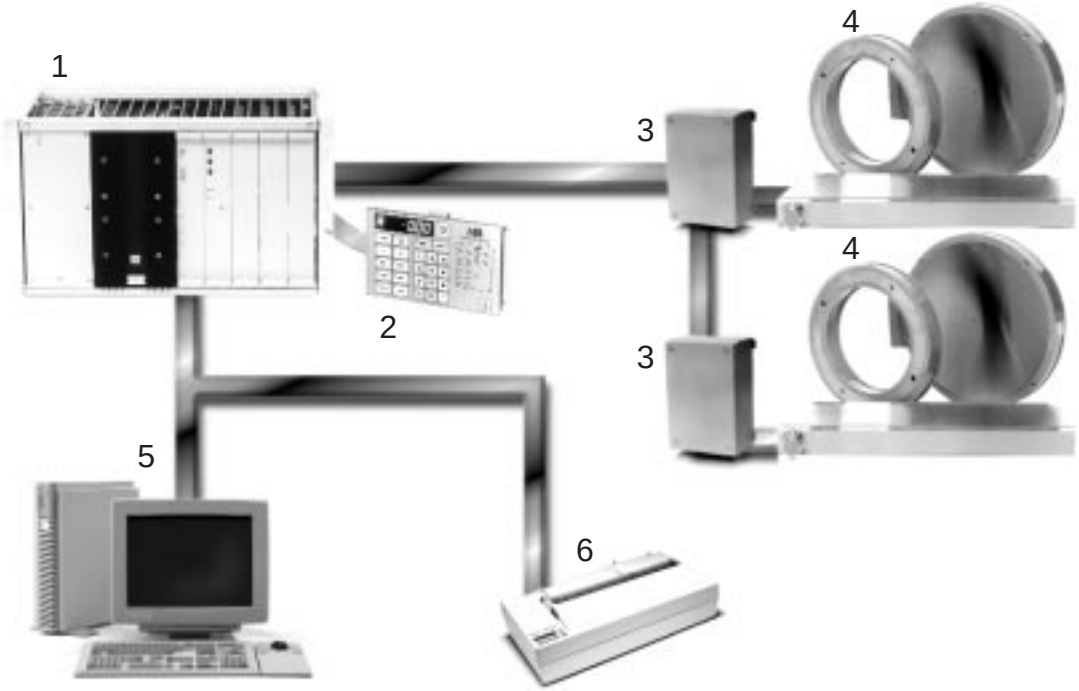
The Millmate Roll Force System has been specially developed to handle very fast force changes in a rolling mill. The system consists of load cells with matching units, panel unit and control unit.

All signal processing is analogue, and the monitoring and control of the analogue signal is digital. The digital part of the system also contains functions such as signal path testing and signal parameter adjustment.

The system contains a microprocessor to handle the digital functions. All communication with the system and all signals that influence the operation of the system are controlled and processed by the microprocessor.

Microprocessor technology enables the operator to communicate with the measurement equipment and, for instance, to obtain rapid reports on its condition.

If the operator activates the SYSTEM TEST function, the voltages, currents, insulation levels, trancducer operation, etc. of the entire system are tested.



The block diagram shows the active parts of Millmate Roll Force System:

1. Control unit
2. Panel unit
3. Matching unit
4. Load cells
5. Computer/VDU
6. Printer

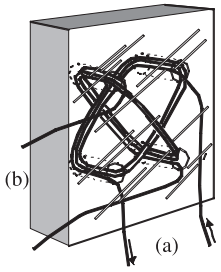
Units 5 and 6 are external units that can be connected to the system via its standard V24 interface

The operation of the Millmate Roll Force Load Cells are based on the well-known Pressductor® Technology, the magnetoelastic effect, according to which the magnetic properties of steel are influenced by mechanical forces acting on it. The transducer in the load cell (see illustrations) has four holes through which pass two windings wound so that they form a right angle with each other and positioned at an angle of 45° to the direction of the force to be measured.

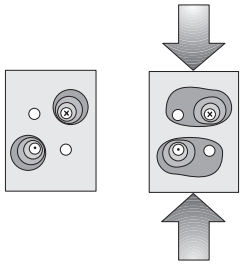
One of the windings (the primary, a) is supplied with alternating current and the other (the secondary, b) is a measuring winding. Since the two windings are at right angle to each other there is no magnetic coupling between them as long as there is no load on the transducer. However, if the transducer is subjected to a mechanical force, the permeability of the material for the magnetic flux is reduced in the direction of the force. This gives rise to a change in the symmetry of the magnetic flux, so that a voltage is induced in the secondary winding.

Up to a given load, the induced voltage is proportional to the load. In Millmate Roll Force Load Cells there can be up to 1500 transducers, so that even if the load is unevenly distributed, the measurement result will nevertheless be correct.

In a Millmate Roll Force Load Cell the transducers are equivalent to the load cell. The load cell is made from specially developed stainless steel electro-sheet with the profile shown in the illustration. The unique Pressductor® Technology makes it possible to design the measurement zone optimally with slots between measurement zones to overcome the effect of lateral forces. Among other benefits, this design approach also minimises the height of the load cells.



Pressductor® Technology
The transducer is energised by the primary winding (a). A voltage proportional to the applied force is generated in the secondary winding (b).



The measurement principle is based on the magnetoelastic effect, according to which the magnetic properties of a material are influenced by mechanical stress.

Installation Arrangements

To achieve the best possible measurement results, certain basic rules must be observed when installing the load cell:

- The entire force must pass through the load cell.
- The force must be measured as close to the source of the force (the roll gap) as possible.
- The load cells must be protected to the greatest possible extent from high bending, lateral and torsional forces.

In most mill stands the roll gap is controlled with hydraulic positioners and/or mill screws. Load cells can be installed in several different ways, but the preferred arrangement, from both the financial and technical points of view, is usually to install the load cell under the mill screw.

Currently there are three types of load cells in the product range, load cells for installation under the mill screw, between the mill nut and the mill stand and those for installation under the lower back-up roll bearing.

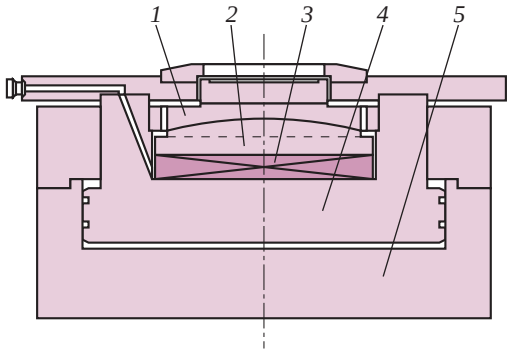
ABB has long experience of load cell installations

It is essential to take every factor into account if an optimal installation is to be achieved. For instance, good load distribution over the surface of the load cell is essential. ABB has many years of experience of installing load cells in all types of rolling mills, and uses modern calculation methods such as the Finite Element Method (FEM) to work out the best solutions in every individual case. This, together with the fact that the Millmate Roll Force Load Cells have been specially designed for roll force measurement, provides the right conditions for the best possible results.

Installation with hydraulic positioners

In installations with hydraulic positioners, the load cells can be integrated with the other mechanical parts of the positioner, i.e., in the moving piston. Since the positioner is a precision-made unit, the tolerance requirement of the load cell can easily be met.

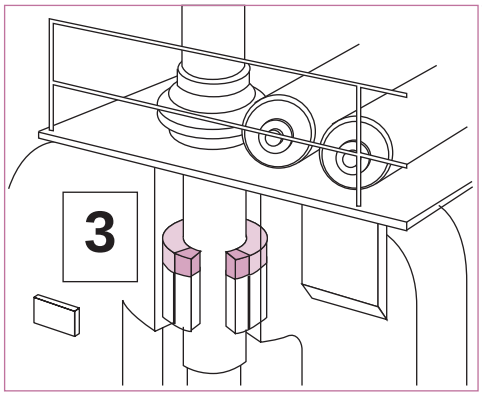
Even the hydraulic pressure ensures that the load is properly distributed.

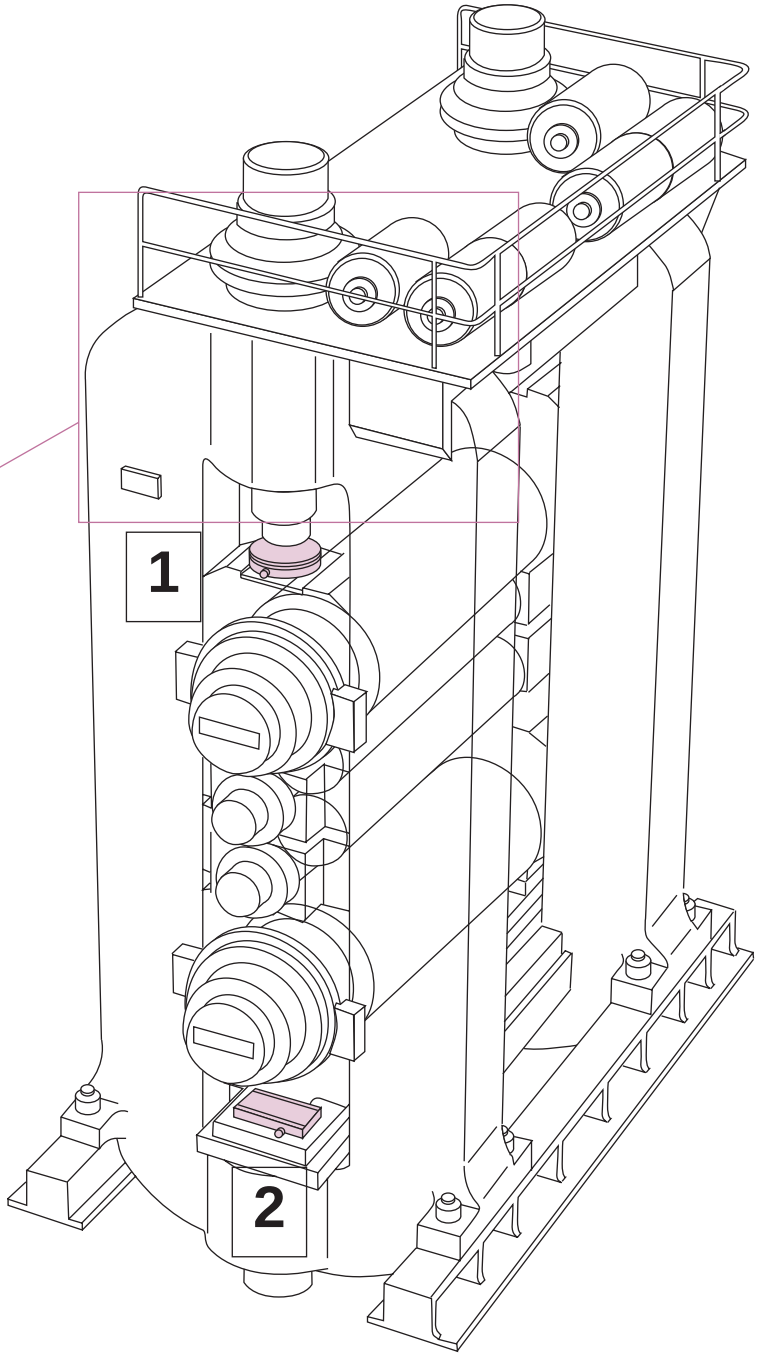


1. *Bearing plate*
2. *Pressure plate*
3. *Load cell*
4. *Plunger*
5. *Cylinder*

1. Under the mill screw

For installation under the mill screw, the load cell can be combined with thrust bearings and pressure plates into a package movably attached to the mill screw; this makes for easier roll changing. The arrangement gives good force distribution, simple, inexpensive installation and easy servicing. In addition, there is no need to machine any surfaces on the roll stand. However, the arrangement does take up space in the roll window.





2. Under the lower back-up roll bearing

There must be a sufficiently large flat surface on the lower part of the roll stand if the load cell is to be installed under the lower back-up roll bearing, but this arrangement has the advantage that there is no need to pay particular attention to the load cell on the roll changing, and it is well protected.

3. Annular load cell between the mill nut and mill stand

This variant makes it possible to measure even if the space under the mill screw and under the lower back-up roll bearing is insufficient. This arrangement also has the advantage that there is no need to pay particular attention to the load cell on the roll changing, and it is well protected.

Description of the Millmate Roll Force Load Cells

Millmate Roll Force Load Cells contain no moving parts and are designed for very severe duty.

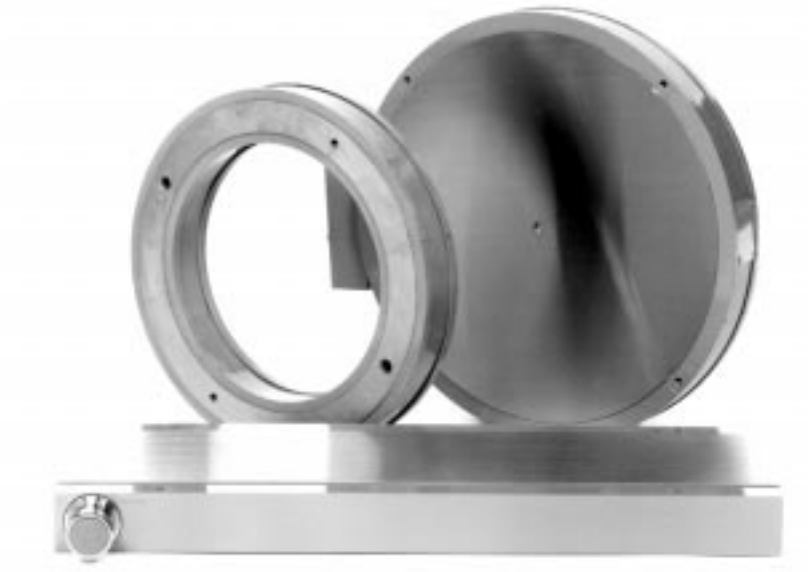
Millmate Roll Force Load Cells have a core consisting of highstrength stainless steel laminations bonded together under high temperature and pressure with an extremely strong oil- and chemical-resistant epoxy adhesive. They therefore contain no moving parts and are designed for very severe duty. The cables for primary and secondary windings are in fluoroplastic-insulated, resistant to oil, humidity and dirt.

The built-in calibration and temperature compensation of the load cell are made up of high-stability components encased in a protective box of fluoroplastic.

Due to its low impedance and high output signal the Millmate Roll Force Load Cell has extremely low sensitivity against insulation defects and maintains its measuring accuracy down to 10 kΩ insulation level.

The load cell output signals are calibrated for full interchangeability between load cells of the same type and size. The various types and the wide load range will cover practically all conceivable roll force measurement applications.

The product range includes rectangular, annular and circular load cells in several standard sizes, with measuring ranges from 0.63 MN to 60 MN.



Circular load cells

A circular Millmate Roll Force Load Cell of type PFVL 101C is generally used for installation under the mill screw.

Shrunk-on steel rings protect the load cell windings and underlying components.

There is a choice of core diameters in multiples of 30 mm, giving 23 different standard sizes for forces between 1.6 and 60 MN.

Rectangular load cells

Rectangular load cells type PFVL 101V are primarily used for installation under the lower back-up roll bearing, but can in certain cases also be used under the mill screw.

The load cell can be adapted to required dimensions, and the length is chosen as a multiple of 30 mm. For load cells longer than 900 mm, the chosen length must be a multiple of 60 mm. The width is chosen as a multiple of 30 mm.

This load cell type is available in standard sizes from 0.63 to 56 MN.

Annular load cells

Annular load cells type PFVL 101R are usually installed between nut and roll stand. The annular load cell consists of measurement plates wounded on an annular iron core, after which an outer iron ring is shrunk on to the load cell to protect the windings and the components below it.

Standard sizes of annular load cells are available from 2 to 28 MN and listed in the table on page 15. Load cells with other dimensions can be manufactured to order.

Data

Accuracy class	% of F_{nom}	±0.5	Compensated for min. error	+20 – +80°C
Linearity deviation	% of F_{nom}	≤±0.5	Zero point drift	≤±0.01%/°C
Hysteresis	% of F_{nom}	≤0.2	Sensitivity drift	≤±0.01%/°C
Repeatability error	% of F_{nom}	≤±0.1	Working temperature range*	-10 – +90°C
Compression	(mm at F_{nom})	0.05	Storage temperature range	-40 – +90°C
Calibration error		0.1%	**) Max. permitted temp. short term*	*+110°C*

Overload capacity

The figures apply provided that the force is uniformly distributed over the load cell surface, at a nominal force equivalent to 100 N/mm^2 on the pressure surface of the load cell. In certain cases it may be appropriate to dimension the load cell differently, and a higher overload capacity can then be achieved.

Highest permissible load without permanent change of data.	*Highest permissible single loading without mechanical damage to the load cell.*
300% of nominal load	*700% of nominal load*

Definitions

Nominal load (F_{nom}) is the load for which the load cell is dimensioned and calibrated, i.e. the sum of the stationary load and the maximum measured load in the measuring direction.

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 is the maximum deviation from a straight line drawn between the output values of zero and nominal load, related to the nominal load.

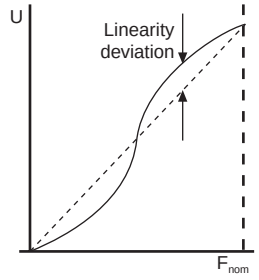
Hysteresis is the maximum deviation of the output signal at the same load during a cycle from zero to nominal load and back to zero, related to the sensitivity at nominal load. The hysteresis is proportional to the cycle.

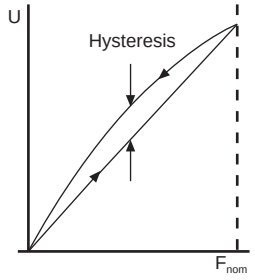
Repeatability error is defined as the maximum deviation between repeated readings under identical conditions. It is expressed as a percentage of the sensitivity at a nominal load.

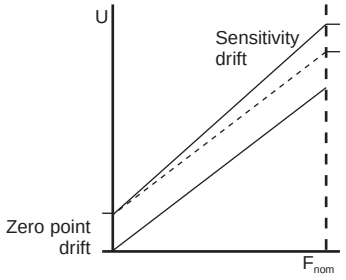
Compression is the total reduction in the height of the load cell when the load is increased from zero to nominal load.

Zero point drift is defined as the drift in the output signal when there is no load on the load cell.

Sensitivity drift is defined as the drift in the output signal at nominal load, excluding the zero point drift.







Control Unit

PFVA 131
For induvidual measurement of two load cells.

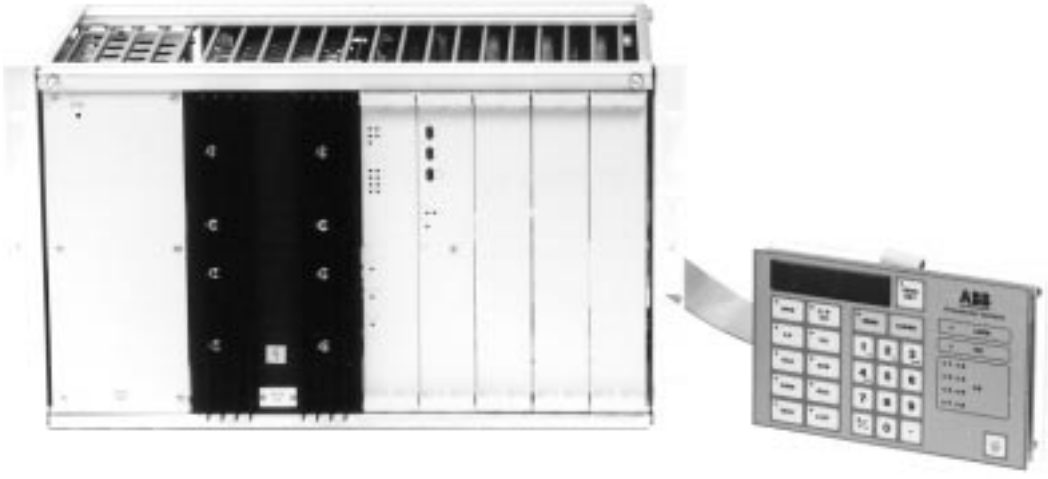
PFVA 131S
For induvidual measurement of four load cells.

The control unit of the Millmate Roll Force System both controls and monitors the measuring equipment and its functions. The operator uses a panel unit to communicate with the system, i.e., to give orders, to read and alter data, to obtain status information and so on.

The system can be remotely controlled from the operator's control cabin or directly from an overriding computer.

Microprocessor technology makes it possible to monitor the entire system continuously. In addition, by activating the SYSTEM TEST function, the operator can himself test the voltages, currents, insulation level, transducer operation, etc., of the entire system. This function can also be activated by an overriding computer.

A Millmate Roll Force System can be built up in various ways. Several control units can be installed in the same cabinet.



Communication with computer or other equipment

Via its microprocessor, the Millmate Roll Force System can communicate with an overriding computer, as well as printers and visual display screens.

Communication goes via a V24 interface, so that messages may be both sent and received. This means that an overriding computer can control the Millmate Roll Force System in the same way as an operator at the panel unit.

System messages and data can be obtained in the standard ASCII code for direct display on a screen or output to a printer.

Digital inputs/outputs

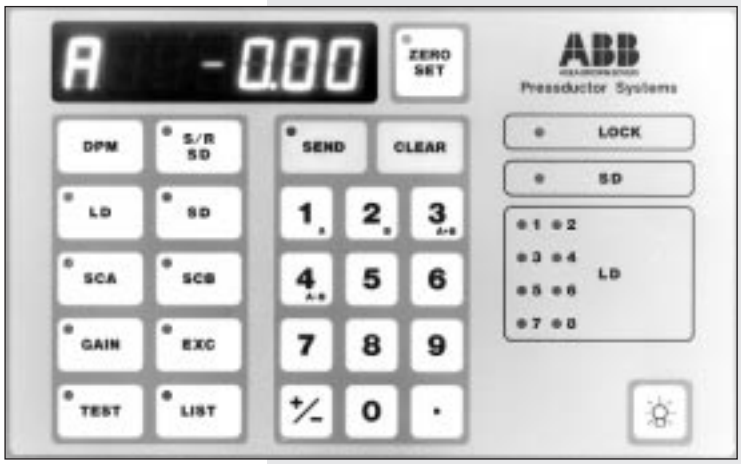
The digital inputs are used to activate a number of the system functions, including zero setting, major system test and single load cell operation.

The digital outputs are used to give information on the status of the different parts of the system. Statuses that can be monitored include: step detector, level detector, single load cell operation, load cell supply, system locking and system errors.

Manual communication with the Millmate Roll Force System takes place via a panel unit. The operator communicates with the system via pushbuttons, LEDs and a digital display.

The panel unit has the following control and indication functions:

- Function pushbuttons. All pushbuttons are equipped with LEDs for status indication.
- Numerical keys for the entry of numerical data.
- SEND. Used to initiate transmission of data to the system. The LED of this pushbutton lights up if transmitted data are not accepted by the system.
- CLEAR. This pushbutton is used to change data already entered. It can also be used to return to previous prompts.
- LEDs for status indication of lock, step and level indicators.
- Seven-digit display.



Functions

With the panel unit, a number of functions can be activated by entering a number on the numeric keypad. For some of the most commonly used functions there are dedicated keys on the panel unit. These are shown on the right hand. ⇒

ZERO SET
The signals from both load cells are reset to zero on this command.

DPM
Digital Panel Meter. The present signal/load is displayed on the selected channel in the selected units.

LD
Level Detector. Eight level detectors, which can be individually allocated to any chosen channel. Output signal via optocoupler and LED on panel.

SD
Step detector. Indicates rapid changes in the sum signal. Adjustable time and step height. Output signal via optocoupler and LED on panel.

SCA & SCB
Single Cell A/B. Disconnects one load cell and feeds the signal from the other to both measurement channels. Indication via optocoupler and LED on panel.

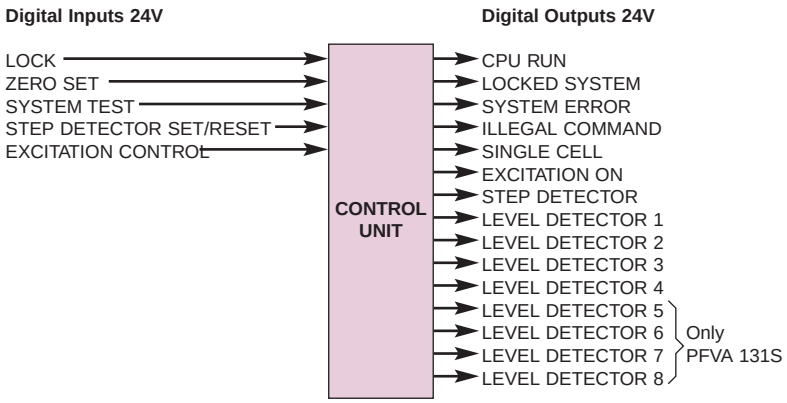
GAIN
Measures the adjustable gain continuously in the relevant measurement channel.

EXC
Switches the excitation current to the load cells on/off.

TEST
Tests the entire system (including cables and load cells) at 31 points and gives diagnoses.

LIST
Function key, the functions of which include listing of error messages and setting the communication format.

LOCK
The equipment can be locked via a digital input to prevent unauthorised changes of system parameters. This is indicated at a digital output and by a LED on the panel.



Mains voltage	100-127, 200-240 V, -15/+10%
Mains frequency	45-65 Hz
Power consumption	800 VA (P.F.≥0.7)

Environmental data

Temperature range	0°C to +55°C
Degree of protection	
MNS Select cabinet	IP 21, ventilated IP 54, sealed
Wall cabinet	IP 65
Min. temp. for transport and storage	-40°C

Performance

Signal outputs	Process and instrument outputs for sum, difference and partial-force signals. The instrument outputs can be switched for voltage or current and are adjustable with potentiometers.
Output signal	10 V for the sum signal (5 V selectable)
Nominal	±5 V for the difference signal (can be amplified 10 times selectable) and 5 V for the partial-force signals. The output signal gain can be adjusted in the range of 0.4 - 2.0 times.
Output current, max.	5 mA total per channel
Ripple, max.	5 mV, p-p 10 kHz bandwidth
Step response time	{0-98%} = 1 ms {0-90%} = 0.7 ms overshoot = 0% instrument output = 1.1 s 0-90%
Limit frequency	600 Hz process output 0.3 Hz instrument output
Non-linearity, max.	0.01% of measuring range
Temperature dependence	
Zero point	0.005%/°C
Sensitivity	0.005%/°C of the actual signal
Mains voltage dependence	0% within the stated range
Frequency dependence	0% within the stated range
Analogue inputs	±5 V DC, one input per channel Impedance 10-20 kΩ
Digital inputs	isolated, 24 V DC, <10 mA
Digital outputs	isolated (opto), 24 V DC max. 200 mA

Serial communication

RS-232/CCITT (V24)	75-9600 baud

Electrical interference environment	As per EMC Directive 89/336/EEC
Electrical safety	As per Low Voltage Directive 73/23/EEC

Assembly arrangements

The electronics of the Millmate Roll Force System are in the form of plug-in units conforming to the international 19” standard.

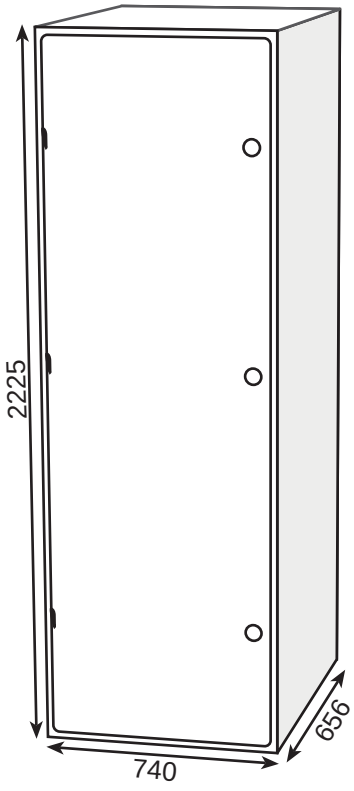
There are two standard installation arrangements:

PFAS 112 Cabinet

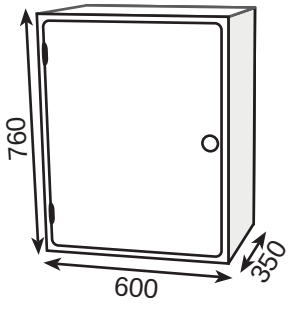
With space for one control unit.

MNS Select Cabinet

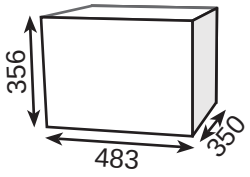
With space for four control units.



MNS Select



PFAS 112



Equipment frame

Matching unit

To convert the excitation current from 2 A to a higher current, 25 A, there is a matching unit PFVO 102 that can be located up to 25 m away from the relevant load cell (depending on the nominal load).

Each load cell requires one matching unit, which is interchangeable between load cells.

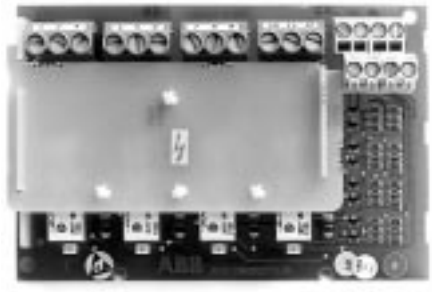
PFVO 202 (2 A to 5 A) is needed for annular load cells with nominal load ≤8 MN.

Insulation amplifier DSTY 101

The insulation amplifier can be used when electrical insulation is required, for example between input and output or between supply and input/output. In such cases the insulation capacity is 3 kV 50 Hz, 60 s.

Supply voltage	+24 V (18-36 V)
Current consumption	70 mA + external load
Signal ranges	
Input	0-±2, 0-±5, 0-±10 V
	0-±20, 4-20 mA
Output	0-±10 V
	0-±20, 4-20 mA

Relay board PFVK 128



Fitted with four relays with one changeover function per relay. The board is supplied with 24 V DC.

Power consumption	20 mA/relay
Contact data	AC: 8 A at 250 V
	DC: 1.2 A at 48 V
	0.2 A at 220 V

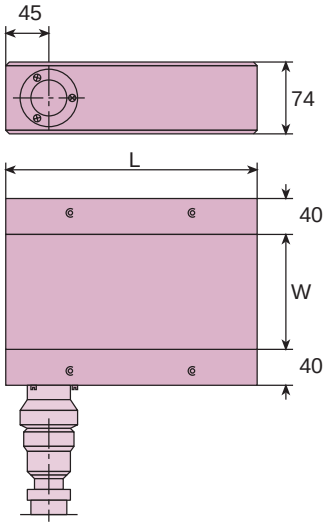
19" aluminium frame DSRA 101

For mounting the insulation amplifier and the relay board.

Rectangular load cells type PFVL 101V

Standard sizes and cable lengths

Nominal load (MN)	Max cable length (m)
0.63	25
0.80	25
1.0	25
1.25	25
1.6	25
2.0	25
2.5	24
3.1	23
4.0	22
5.0	21
6.3	20
8.0	19
10	18
12.5	17
14	16
16	16
18	15
20	15
22	14
25	13
28	12
31	11
35	10
40	8
45	8
50	6
56	6



Length (L) mm		
120	480	840
150	510	870
180	540	900
210	570	960
240	600	1020
270	630	1080
300	660	1140
330	690	1200
360	720	1260
390	750	1320
420	780	
450	810	

Width (W) mm	
70	430
100	460
130	490
160	520
190	550
220	580
250	610
280	
310	
340	
370	
400	

Example
Nominal load 14 MN and a width of 370 mm will be 390 mm long (rounded up from 378).

PFVL 101V, 14 MN,
L=390 mm
W=370 mm

Order as follows:

- Determine the load for which the load cell is to be used and choose from the table the next higher value in the standard range.
- Determine either the width or length of the load cell and calculate the other dimension using the following formula:
  L x W x 0.0001 = F

L = load cell length in mm
W = load cell width in mm
F = nominal load of load cell in MN (taken from the standard series in the table)

The width and length are rounded up to the next higher value in the table.

When ordering, please state:

- *type designation*
- *nominal load*
- *width and length*

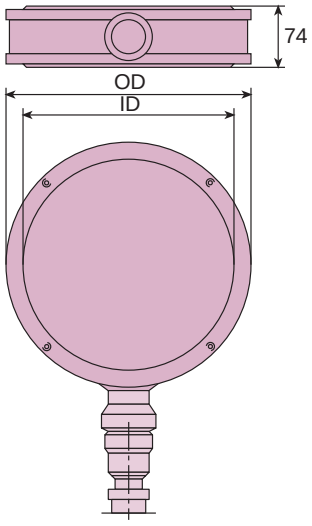
Guide to Ordering

Circular load cells type PFVL 101C

Standard sizes and cable lengths

Load cells are manufactured in the standard range as below:

Nominal load (MN)	ID (mm)	OD (mm)	Max. cable length (m)
1.6	150	210	25
2.5	180	240	24
3.1	210	270	23
4.0	240	290	22
5.0	270	320	21
6.3	300	350	20
8.0	330	380	19
10	360	410	18
12.5	390	440	17
14	420	470	16
16	450	500	16
18	480	530	15
20	510	560	15
22	540	590	14
25	570	620	13
28	600	650	12
31	630	710	11
35	660	740	10
40	720	800	8
45	750	830	8
50	780	860	6
51.5	810	890	6
60	810	890	6



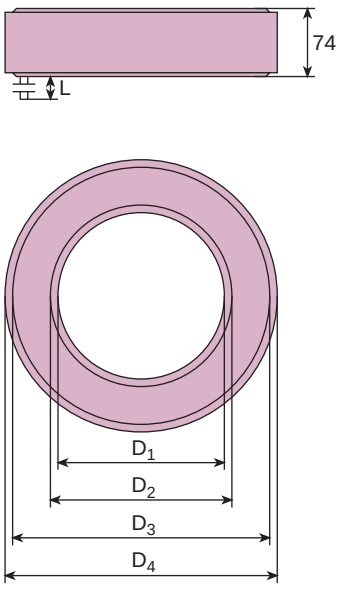
Example
Nominal load 20 MN per load cell. Select 20 MN load cell, dimension OD=560 mm, ID=510 mm

PFVL 101C, 20 MN.

When ordering, please state:
- *type designation*
- *nominal load*

Order as follows:

- Determine the load for which the load cell is to be used and choose from the table the next higher value in the standard range.



Standard sizes and cable lengths

Nominal load (MN)	D_1 (mm)	D_2 (mm)	D_3 (mm)	D_4 (mm)	Max cable length (m)
2	100	130	200	240	75
2.5	100	130	210	250	72
3.1	200	230	300	340	69
4	225	255	340	380	66
5	255	285	380	410	63
6.3	285	315	420	450	60
8.0	320	350	470	500	57
10	355	385	525	555	18
11.2	375	405	550	580	17
12.5	400	430	590	620	17
14	420	450	620	650	16
16	450	480	660	690	16
18	480	510	700	730	15
20	505	535	735	765	15
22.4	535	565	775	805	14
25	565	595	820	850	13
28	595	625	865	895	12

Other dimensions on request

Example
PFVL 101R, 10 MN, D_2=385, D_3=525.

Order as follows:

- Determine the load for which the load cell is to be used and choose from the table the next higher value in the standard range. We can customise load cells if a standard load cell is not suitable for a particular application.
- To calculate the load F for non-standard load cells

$$F=\left(\frac{D_3^2\,\pi}{4}-\frac{D_2^2\,\pi}{4}\right)\times 0.0001 \text{ MN.}$$

When ordering, please state:
- *type designation*
- *nominal load*
- *D_2 and D_3*

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ABB Force Measurement is a division within ABB Automation Products. It provides equipment for accurate, reliable measurement and control in a broad range of applications from steel making to paper converting industries.

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