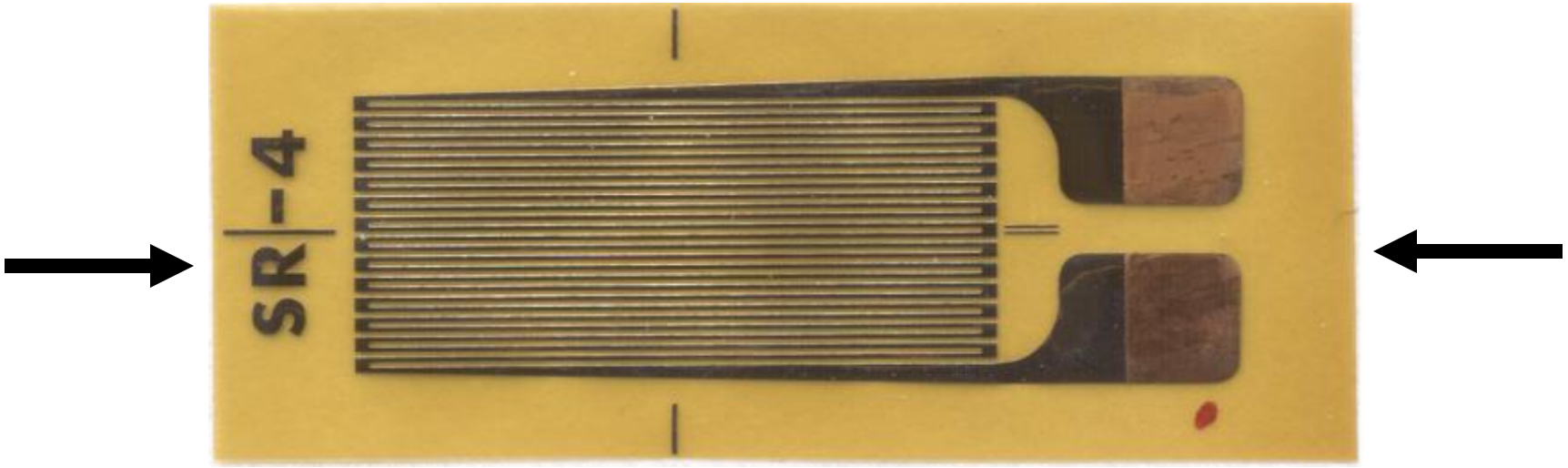
VISHAY PRECISION GROUP

Load Cells

Load Cells Principal
Product Overview
Customized Load Cells
Web Tension

Where the World Goes
for Precision Measurement and Control

Strain Gauge

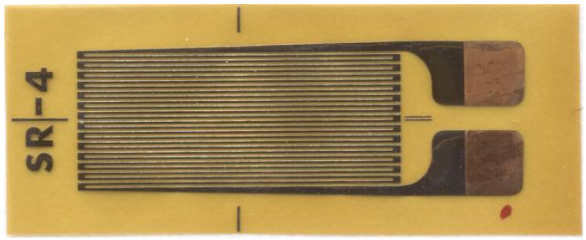


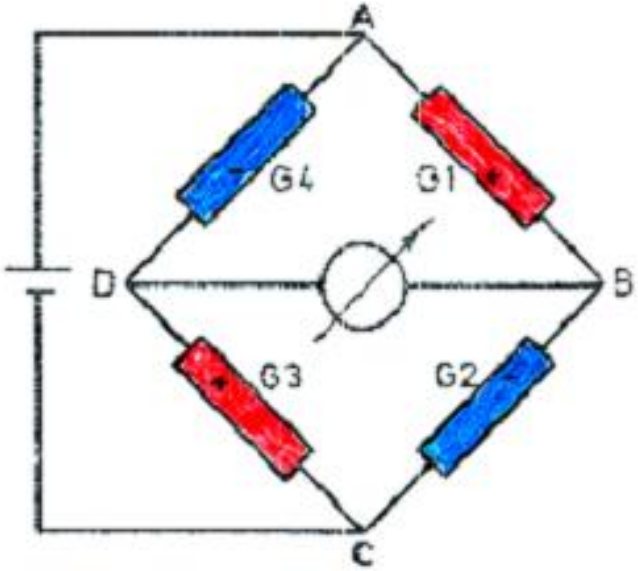
Tension - Resistance increase

Compression – Resistance decrease

Wheatstone Bridge

Four strain gauges are glued to the load cell element so that they follows the elongation of the material.
The strain gauges are connected in a Wheatstone bridge, where the bias can be measured.

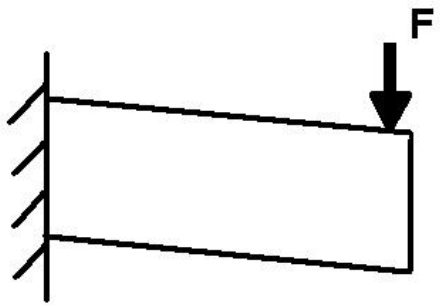


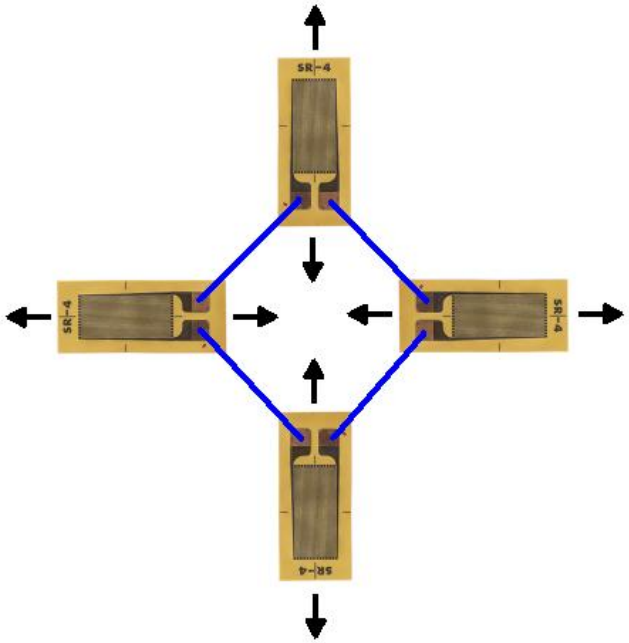


Wheatstone Bridge

The strain gauges are orientated so that two are stretch and two are compressed when the load cell are subjected to a force.

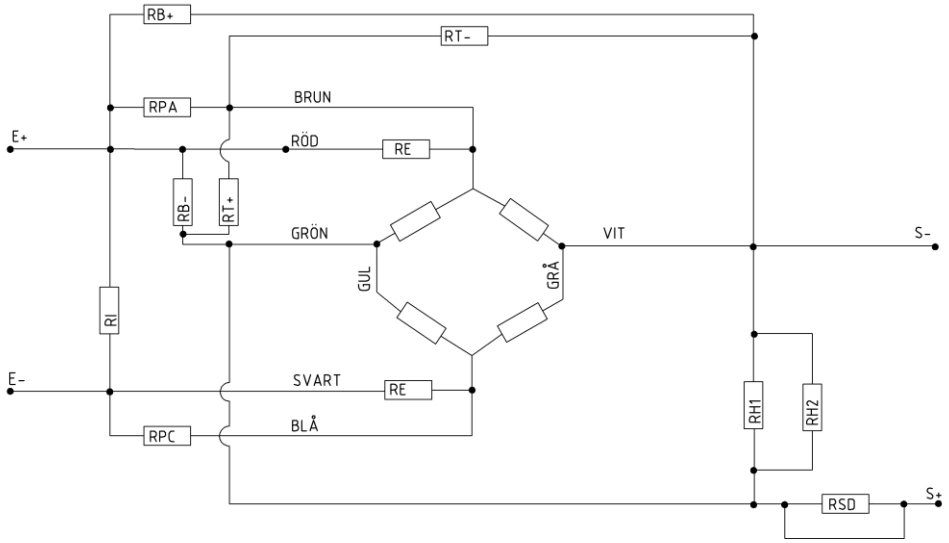
The bias in the bridge is proportional to the applied force.



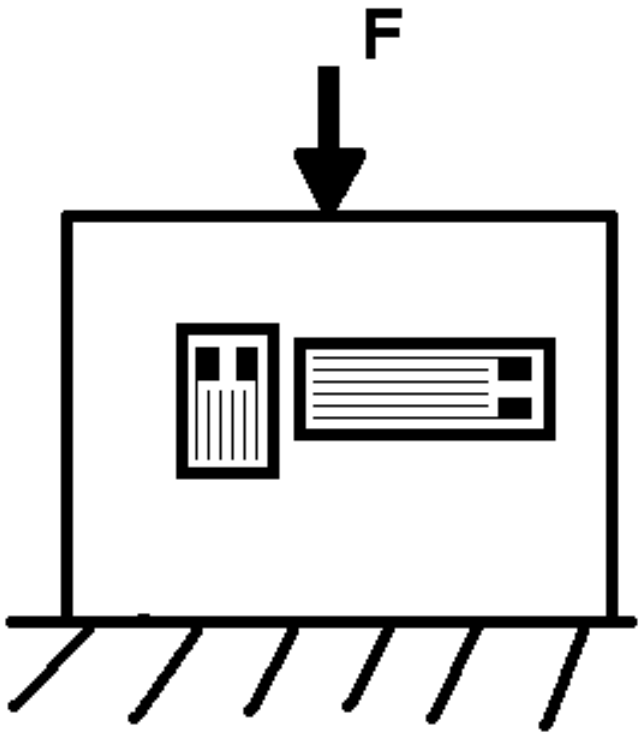


Wheatstone Bridge

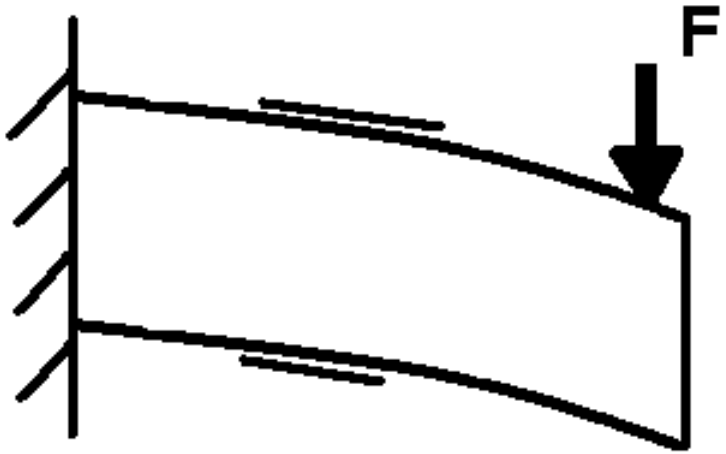
Modulus gauges and resistors are the connected to the bridge for zero and span drift compensation, zero balancing and trimming of output.



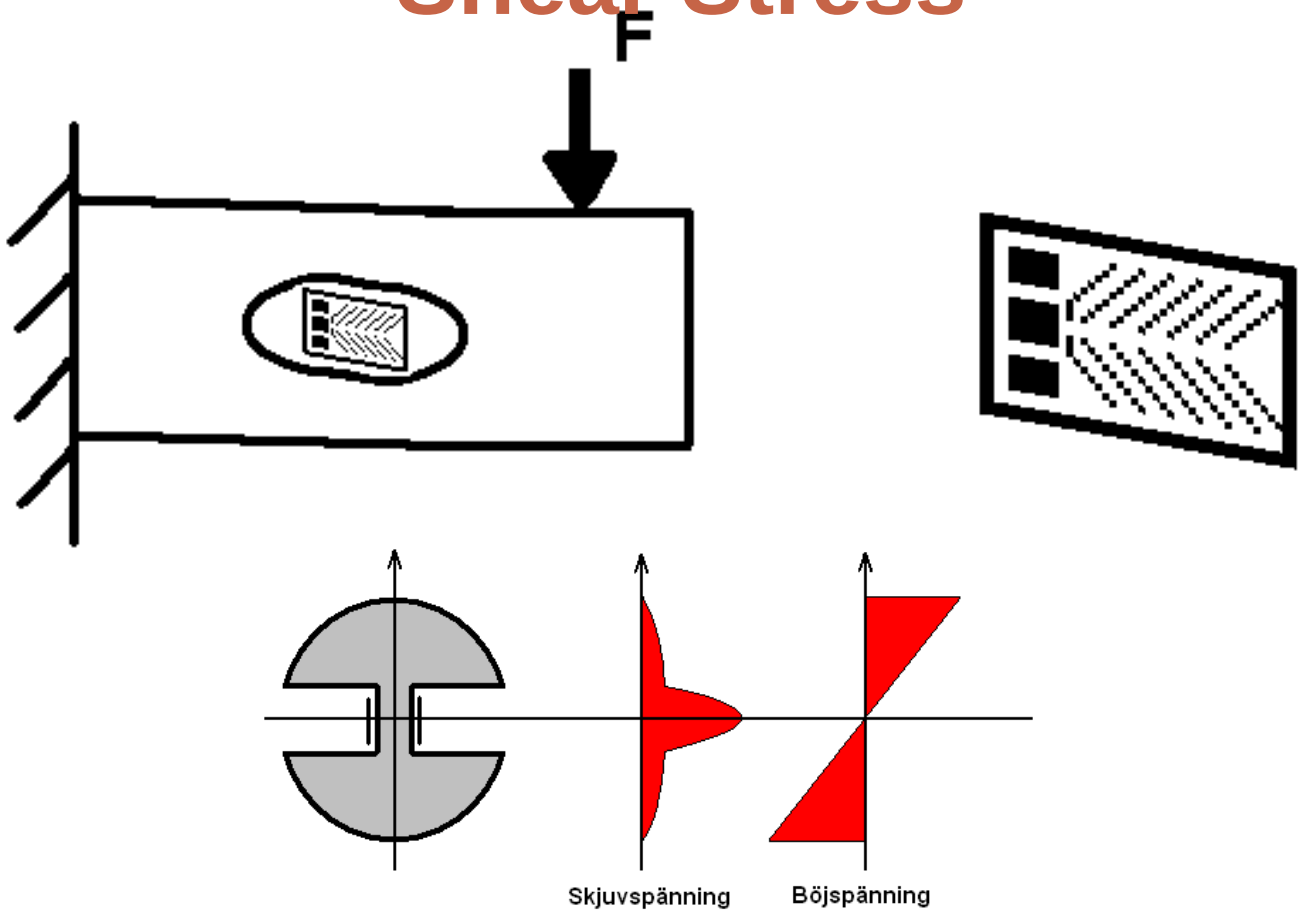
Stress Tension/Compression



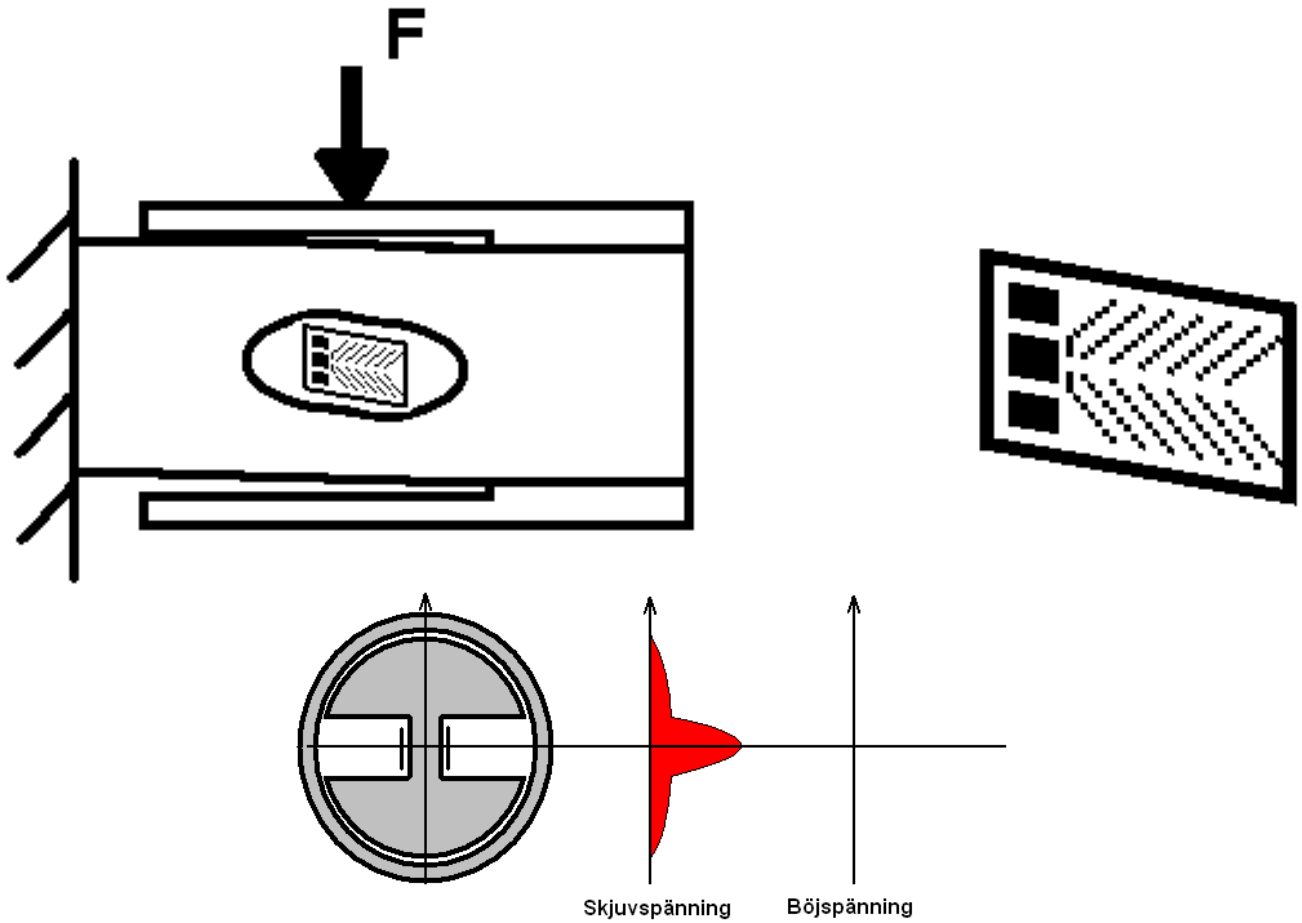
Bending Stress



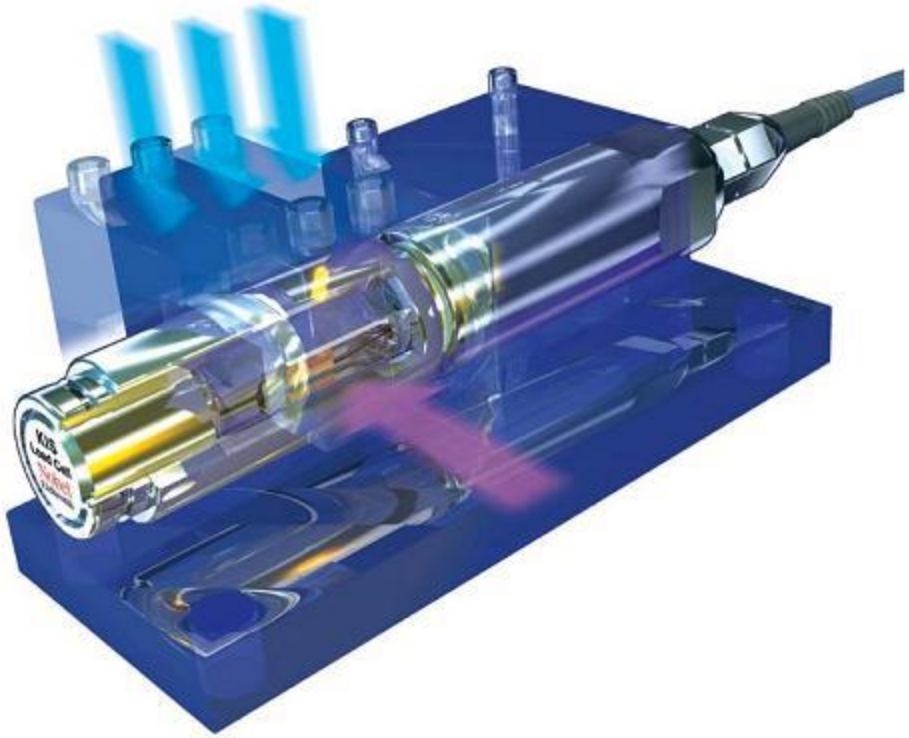
Shear Stress



Shear Stress with Sleeve



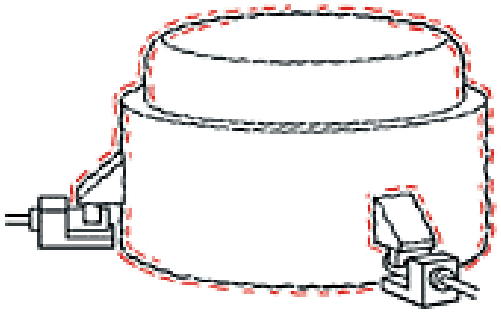
KIS



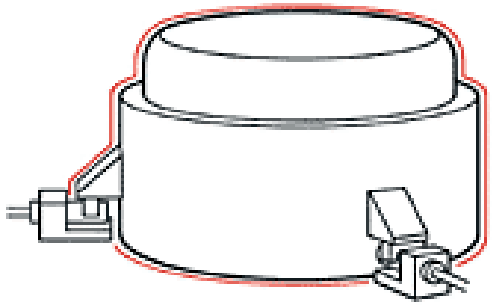
Features of the KIS Load Cell

Without effecting the high accuracy the load can be applied along the load cell.

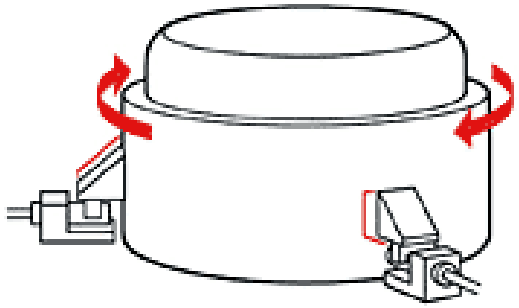
The load cell can withstand 100% side load.



Vibration from agitation

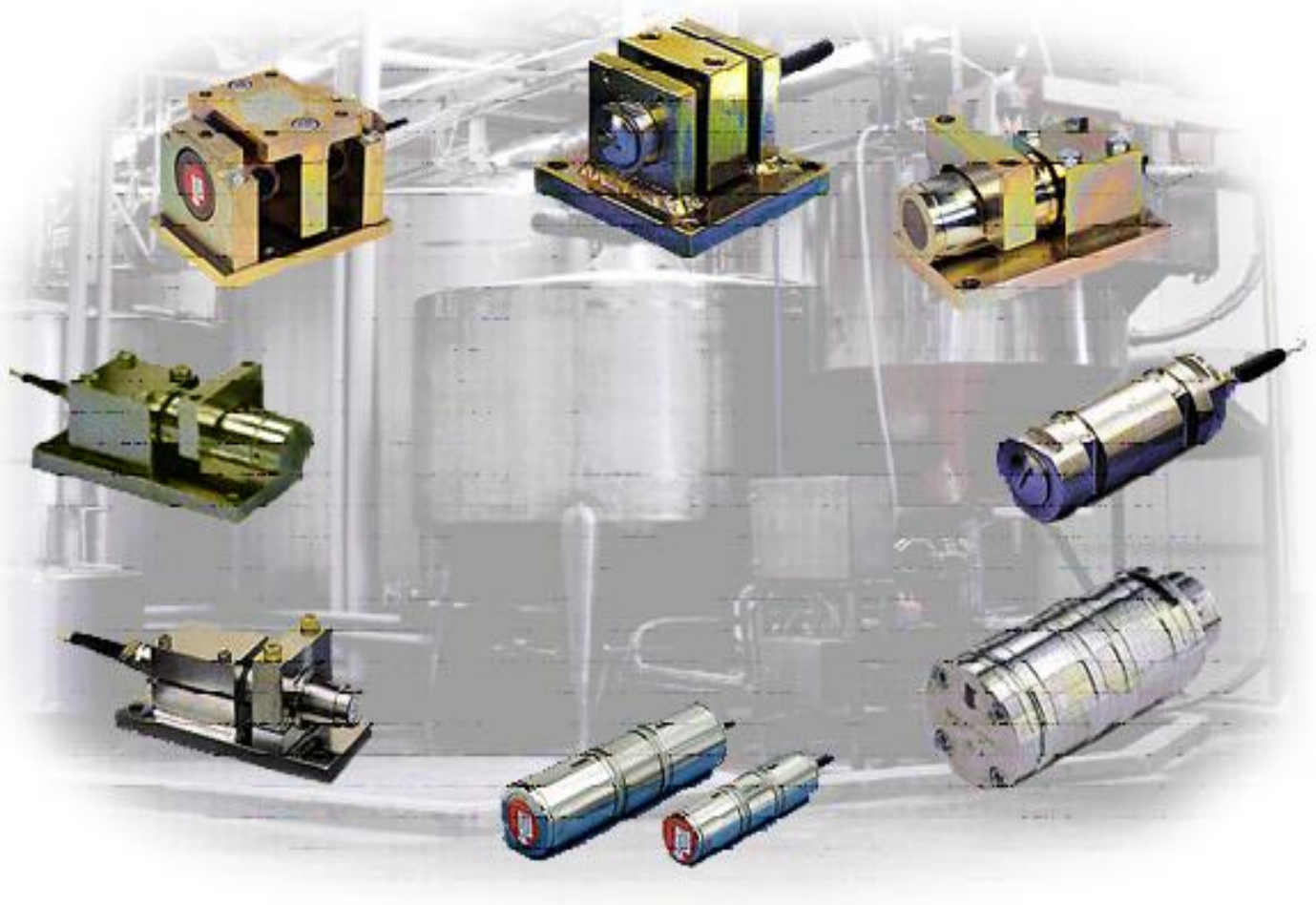


Thermal expansion



Twisting Moment caused by i.g. agitation

Vishay Nobel Products



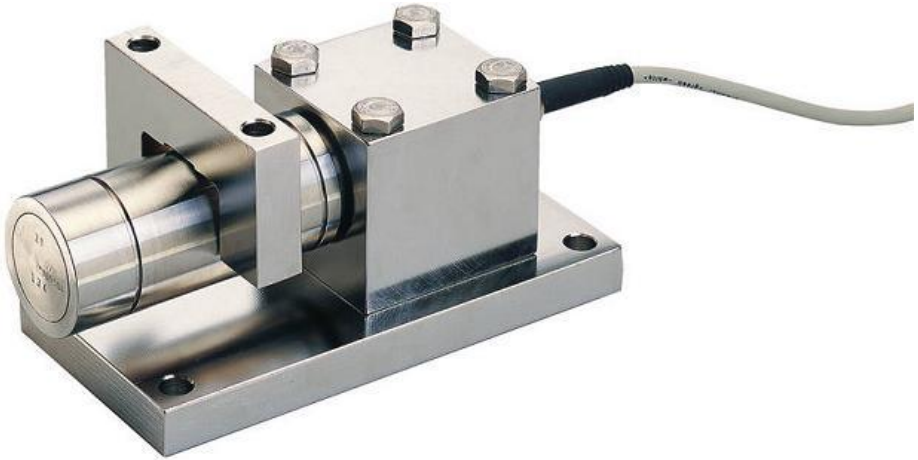
KIS-1, KIS-2, KIS-3 och KIS-11

- **KIS-1**: 50 - 500 kN, Combined Error ± 0,03% of R.L
- **KIS-2**: 1 - 30 kN, ± 0,05% of R.L
- **KIS-3**: 1 - 20 kN (3000d approved), ± 0,02% of R.L
- **KIS-11**: 50, 100 kN (3000d approved), ± 0,02% of R.L

1 - 50 kN Load cell is stainless steel, hardware is stainless steel on demand
100 – 300 kN Stainless steel on demand

KIS-8

- Capacity 1 - 200 kN
- Combined Error ± 0,075% of R.L
- Weigh Module
- Stainless Steel
- Lower Cost than KIS-1, -2 and -3 in Stainless Steel

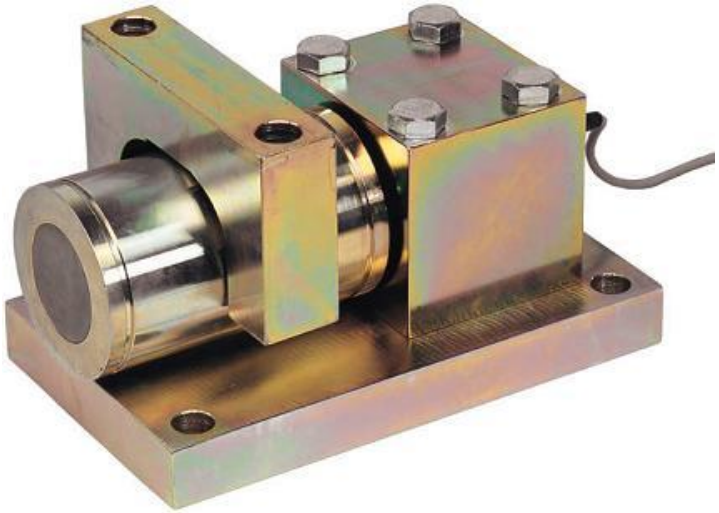


KIS-9

- Capacity 5 - 100 kN
- Combined Error ± 0,1% of R.L
- Weigh Module
- Stainless Steel
- Lower Cost than KIS-8 module

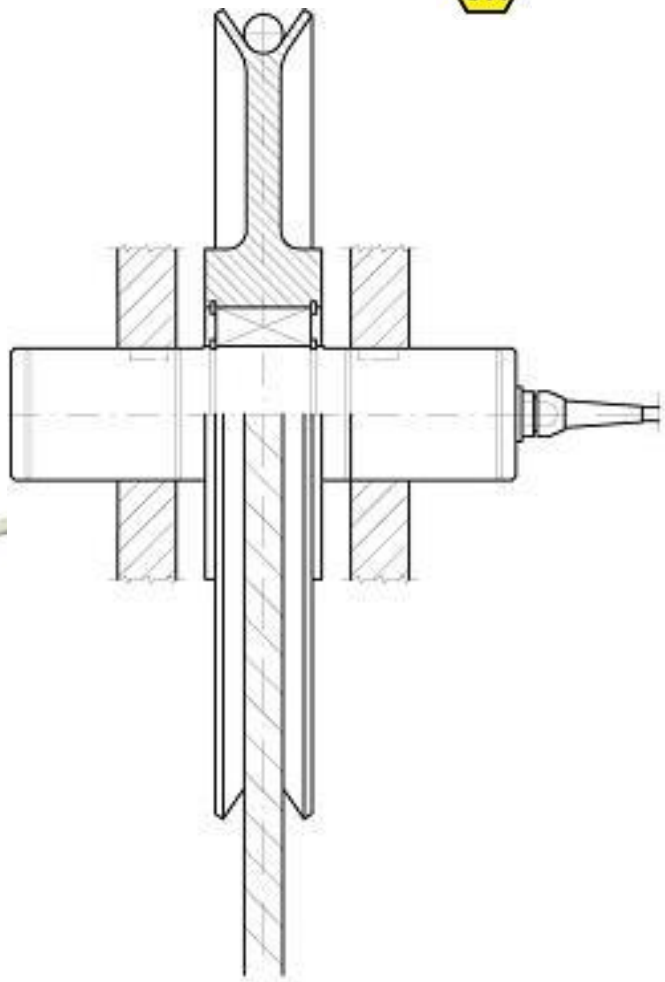
KIM-1

- Capacity 200 kN
- Combined Error ± 0,1% of R.L
- Yellow Chromate Steel
- Lower Cost than KIS-8 module



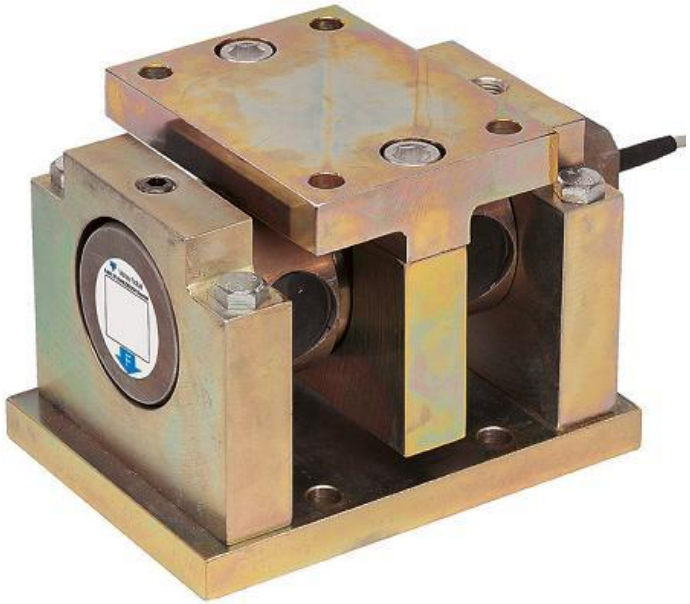
KISD-6R

- Capacity 50 - 1000 kN
- Combined Error ± 0,1% of R.L
- Double Ended KIS-Load Cell
- Stainless Steel



KIMD-1

- Capacity 500 and 800 kN
- Combined Error ± 0,1% of R.L
- Weigh Module
- Heavy Duty Hardware on Demand



KIMD-M

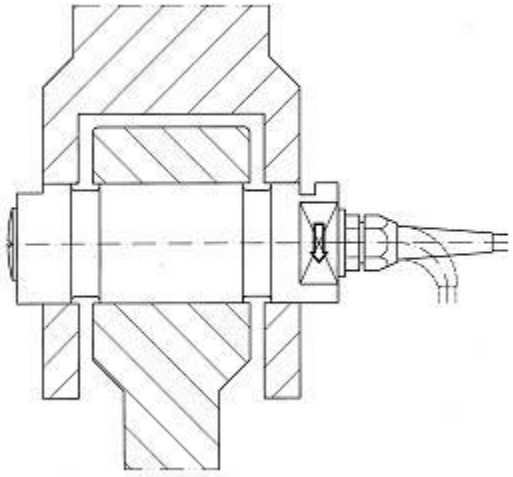
- Capacity 500 to 2000 kN
- Combined Error ± 0,1% of R.L
- Weigh Module
- Floating Yoke

KOSD-40

- Capacity 10 - 500 kN
- Combined Error ± 0,5% of R.L (0,25% in KOM-1)
- Force Measurement – Overload control
- KOM-1 Level Monitoring

KOM-1

KOSD-40



KOSD-101, -107 and –115

- **KOSD-101** and **–107**: Capacity 1000 kN
- **KOSD-115**: Capacity 2000 kN
- Combined Error ± 1,0% of R.L
- Force Measurement – Overload control
- Level Monitoring

CLC-1

- Capacity 250, 500, 1000, 2000 kN
- Combined Error ± 0,1% of R.L
- Yellow chromate alloy steel standard
- Force measurement, weighing etc
- With adaptor plates replaces e.g. Schenk Weigh disk

Vishay Transducers

Vishay Transducers

Compression

Shear beam

Bending Beam

Single Point

S-Load Cell

Special Load Cells

Certain applications requires tailor-made load cells.

These can vary in size and capacity to a large extent.

KIMD 270 t

KIMD 0,5 t

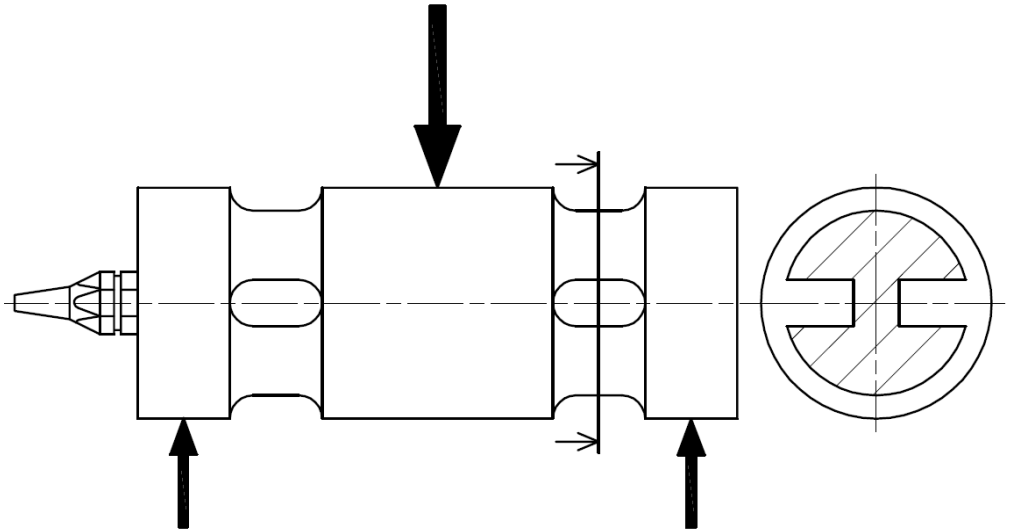
Special Load Cells

- Large and Small load cells:

- Capacities 50 kg – 600 ton
- Diameter 10 mm – 360 mm
- Length 30 mm – 2100 mm

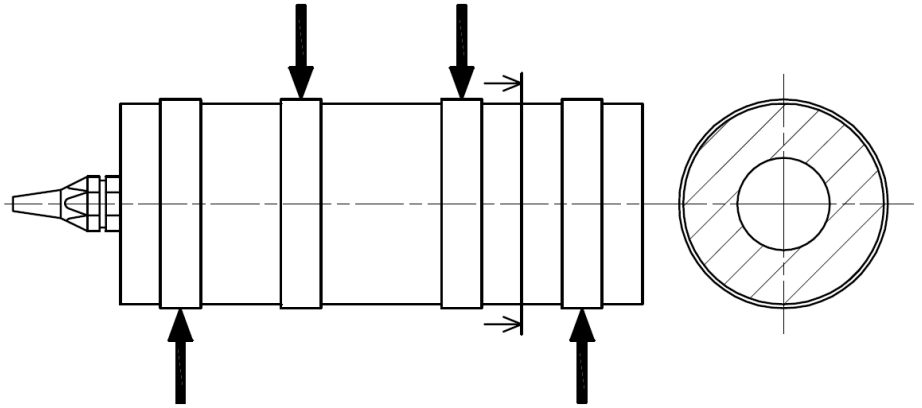
Special Load Cell

KIMD-type



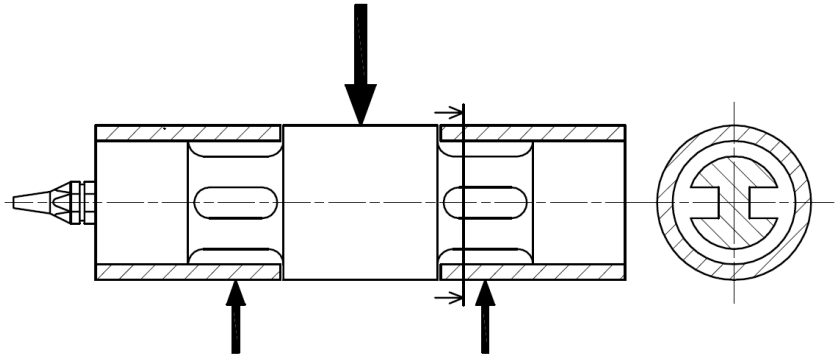
Special Load Cell

KOSD-type



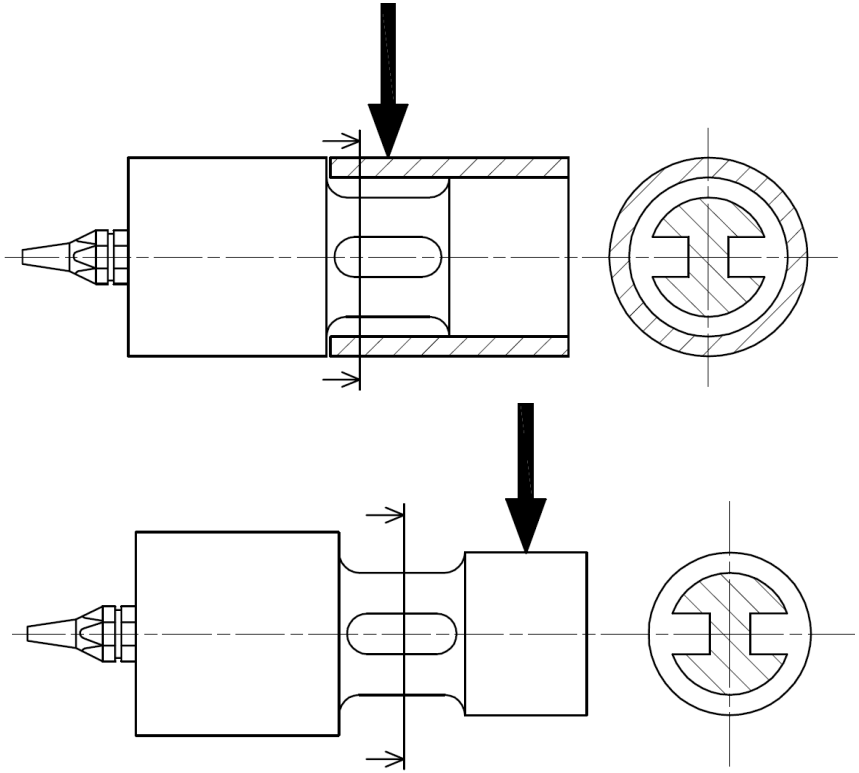
Special Load Cell

KISD-type



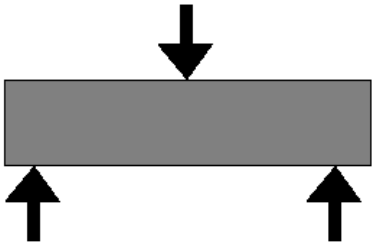
Special Load Cell

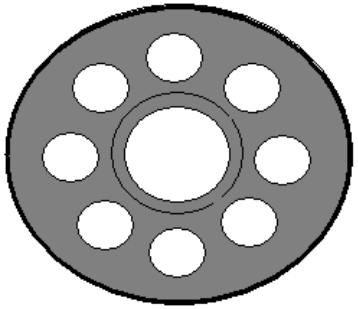
KIS-type



Special Load Cell

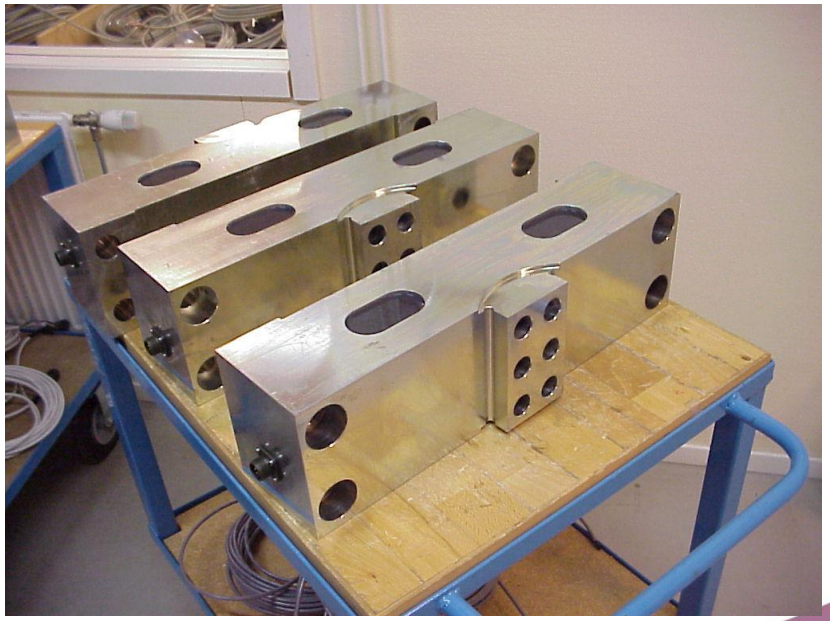
CLC-type



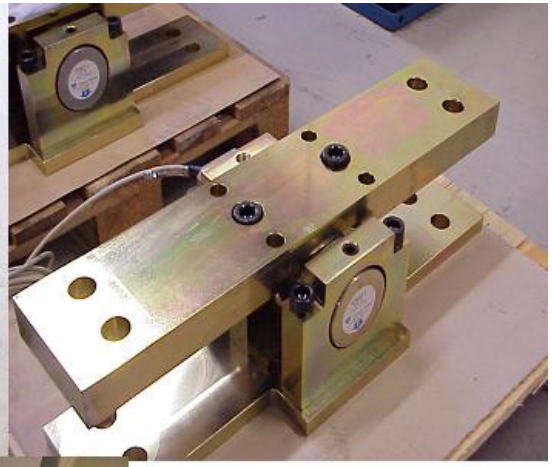


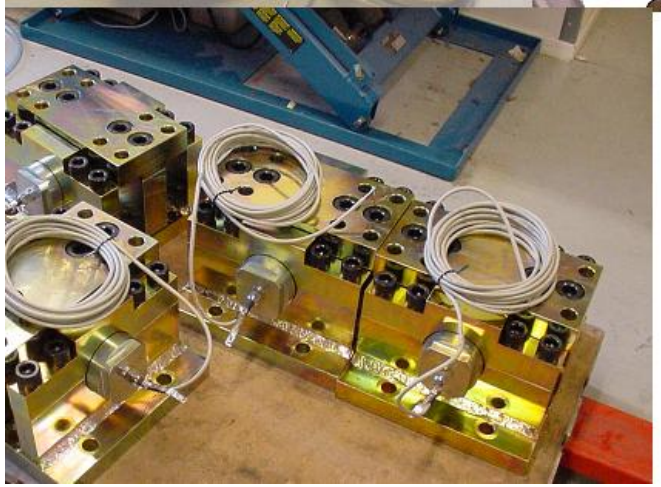
DSA-R

- Replaces Schenk DWB
- Capacity 250 - 2000 kN
- Combined Error ± 0,1% of R.L
- Yellow chromate alloy steel standard
- Fixed load point



Special Mechanics





Special designed
brackets
reinforced mechanics

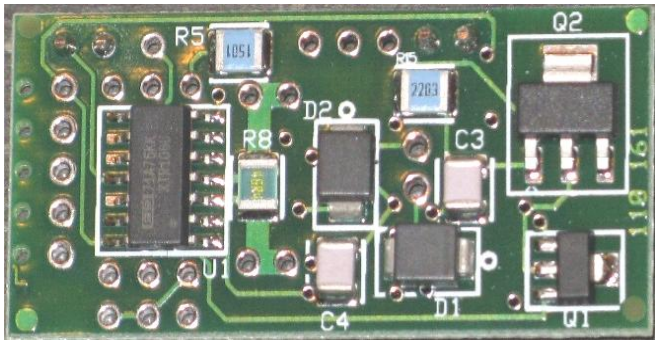
Internal amplifier

- Internal amplifiers are used in areas where the mV/V signal can not be transferred or as a cheap alternative to an external amplifiers.
- The internal amplifier will always be the most sensitive part of the load cell, therefore we recommend to use this only when this is requested and necessary.
- Vishay Nobel has focused on using two alternative analogue 4-20 mA amplifiers, TransAmp and ICA 4S. But if any other output is requested we should be able to provide this as well.

Internal amplifier

TransAmp

- High accuracy 4-20 mA analogue amplifier.
- Response time 2 ms.
- 2 wire.
- Factory linearization is possible.
- ATEX approval for KOSD and KIMD, single and double bridge.



Internal amplifier

TransAmp

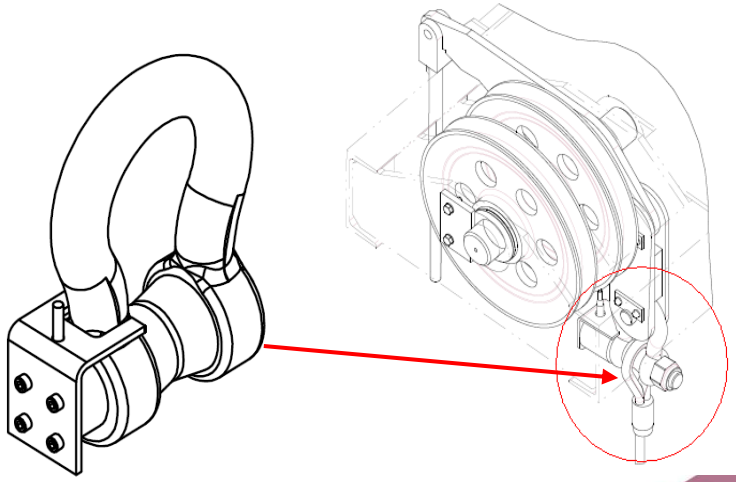
- Typical applications: Offshore, overload protections, crane weighing

Internal amplifier

ICA 4S

- Small and simple analogue 4-20 mA amplifier.
- Four wire.
- Low accuracy
- Typical applications: Overload protection and force measurement load cells.

Special KOSD



Shackle load cell

New inbuilt amplifier

New customer requirements:

- Response time 5ms, 1ms if possible (National Oilwell)
- Operating temperature up to +70 (Lidan Marine)
- HART communication for setup and diagnostics (Aker Pusnes)
- 30 year lifetime (common request, a reliable design usually OK)
- Submersion down to 30m (Aker Pusnes) *(for future design)*
- Profibus PA data communication (Lidan Marine) *(for future design)*
- Meet (unspecified) requirements for offshore EMC environment (ship and oilrig use)
- Withstand (unspecified) shocks and vibrations from:
  - Hanging load variations (offshore crane weighing)
  - Chain load variations (Mooring systems)
- Meet (unspecified) requirements in salt water environment (Mooring systems)
- Output zero adjustment

New inbuilt amplifier

New amplifier main characteristics:

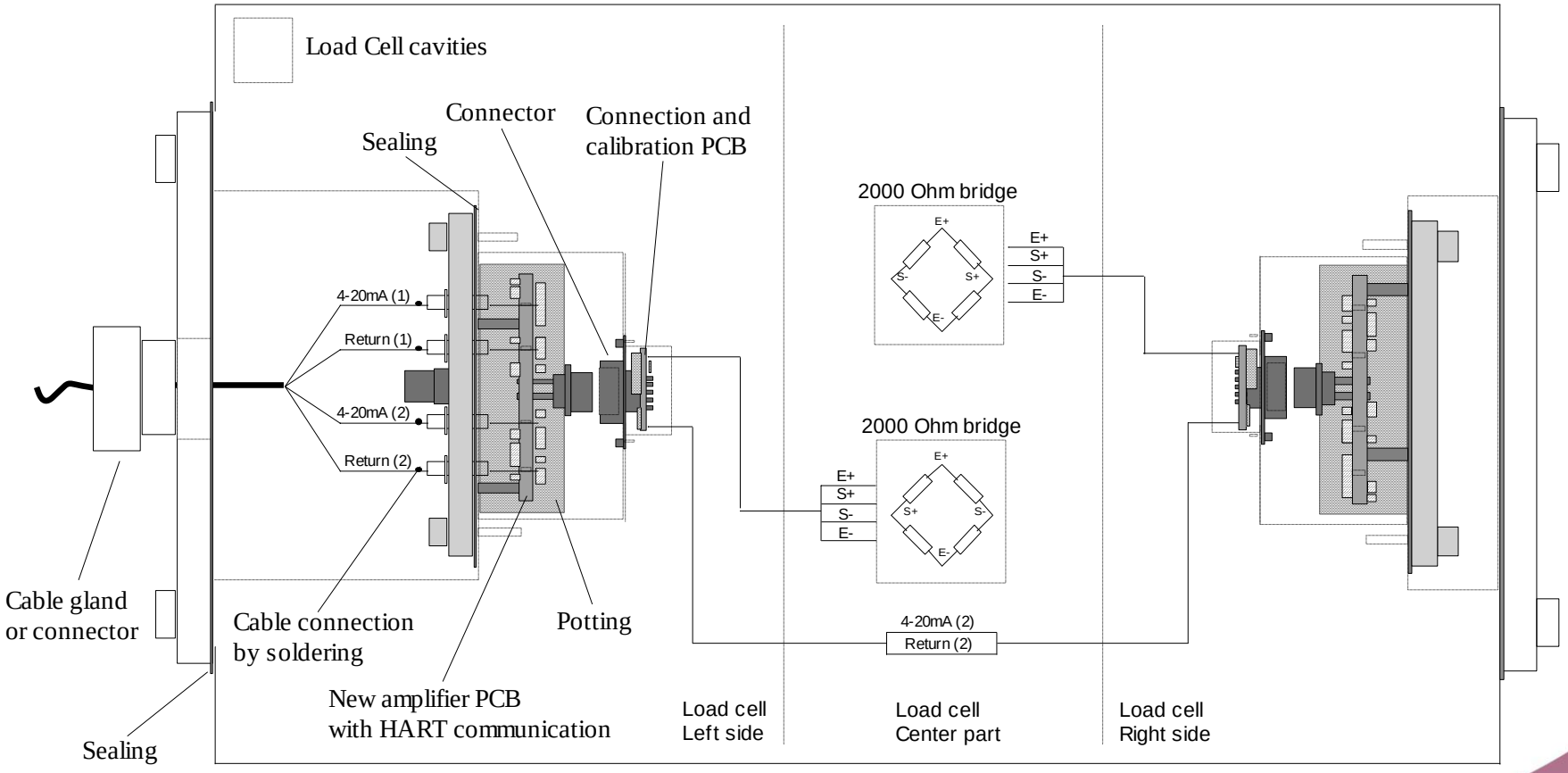
- Ingression protection IP67 mounted in load cell as shown in figure 7
- Accuracy < 0.1% of FS @ operating temperatures with A/D aliasing included
- DC to 29Hz @-3dB current loop bandwidth with minimum -40dB/dec attenuation
- Load cell strain gauge bridge resistance 2000 Ohm ± 10 Ohm
- 16-bit DAC with 4 to 20mA normal and NAMUR NE 043 output error signalling
- < 10 PPM /°C current loop output drift after temperature compensation
- Serial 115200 bit/s CPU FLASH data download support
- Fixed gold plated amplifier unit connector pin interface towards the load cell
- Standard HART 6.0 communication as slave unit
- 1-wire serial calibration memory PCB data amplifier read/write support
- 1-wire serial Load cell temperature amplifier read support
- Low noise gain and 24bit 2000sps A/D differential sensor signal conversion
- Minimum 40% ADC utilisation for ±0.8 to 3.5 mV/V by gain select in 2 steps
- Bridge excitation voltage reference A/D-converter feedback

New inbuilt amplifier

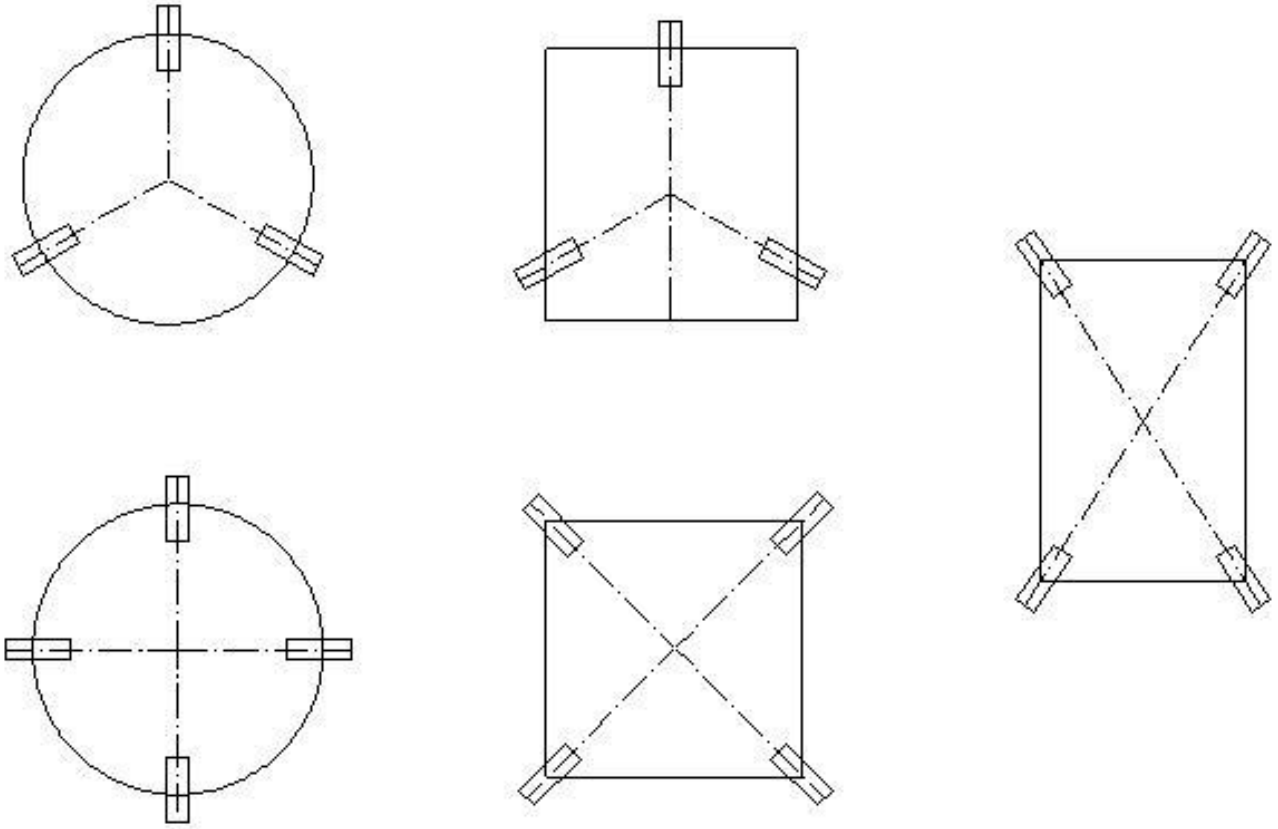
New amplifier main characteristics:

- Total electronic unit current loop power consumption < 34mW
- Load cell bridge excitation voltage > 2V
- PCB mounted on a metal plate with sealing gasket and direction pins
- Start up time < 2s

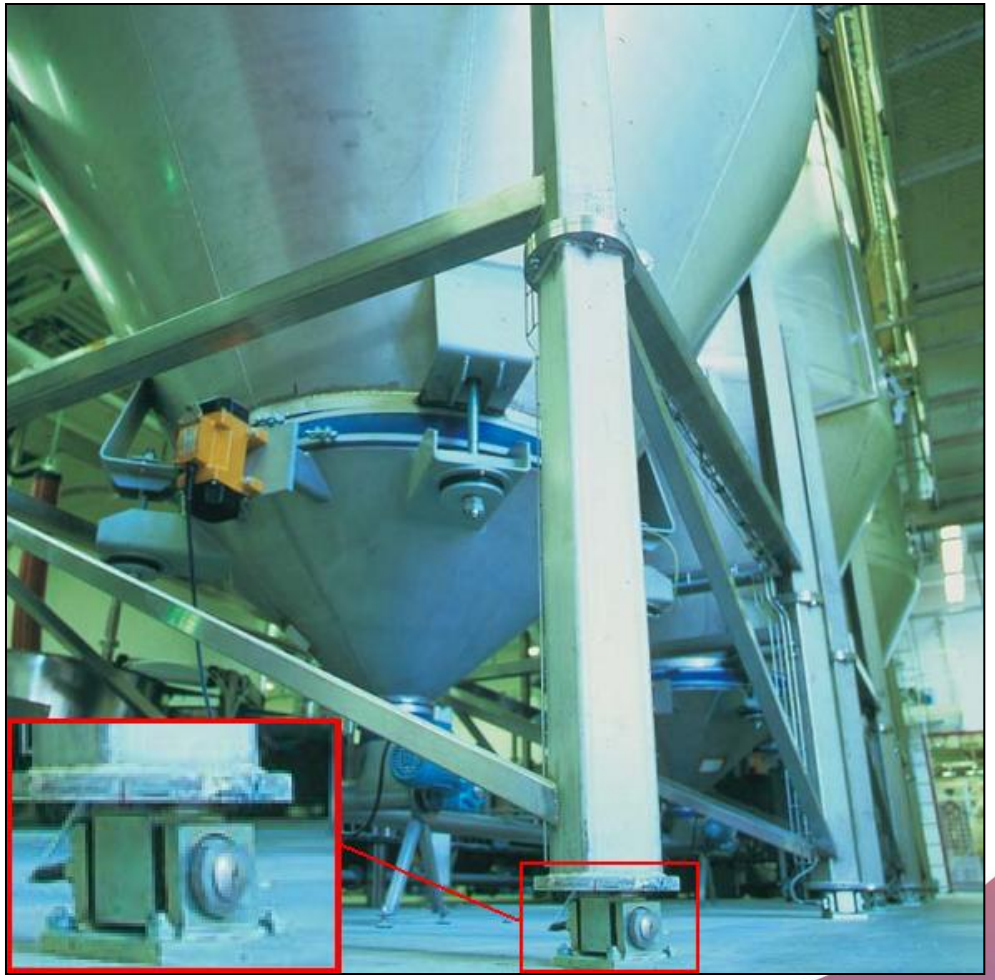
New inbuilt amplifier



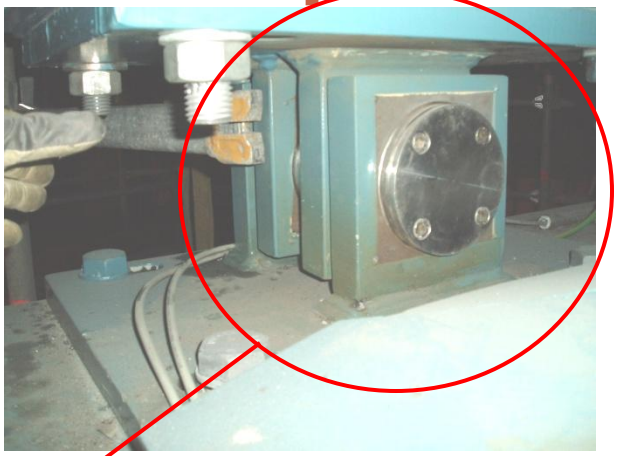
Self locking installation, that allows thermal expansion

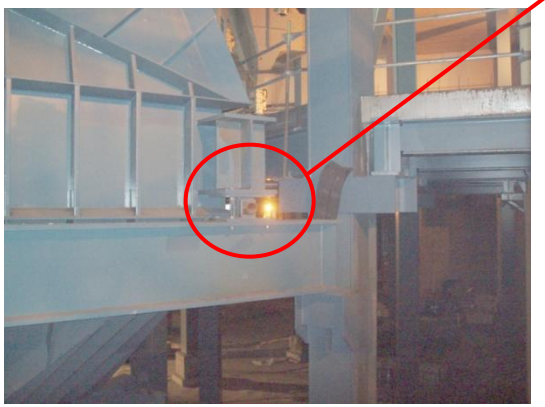


Installation example

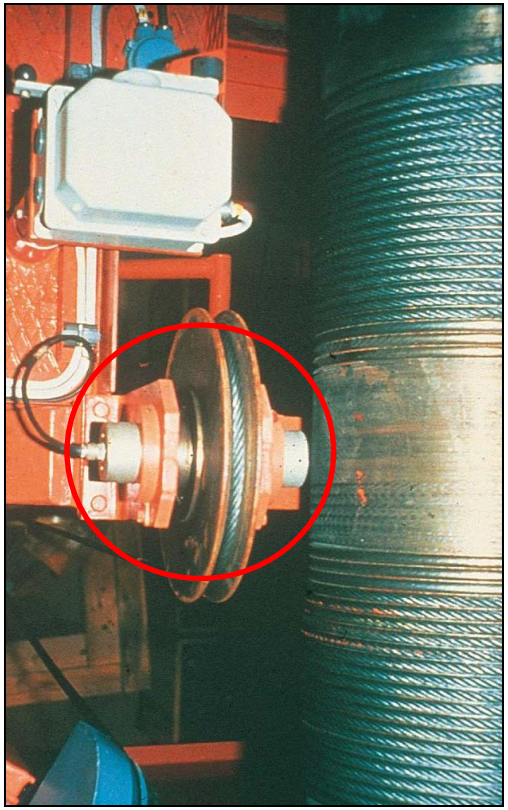


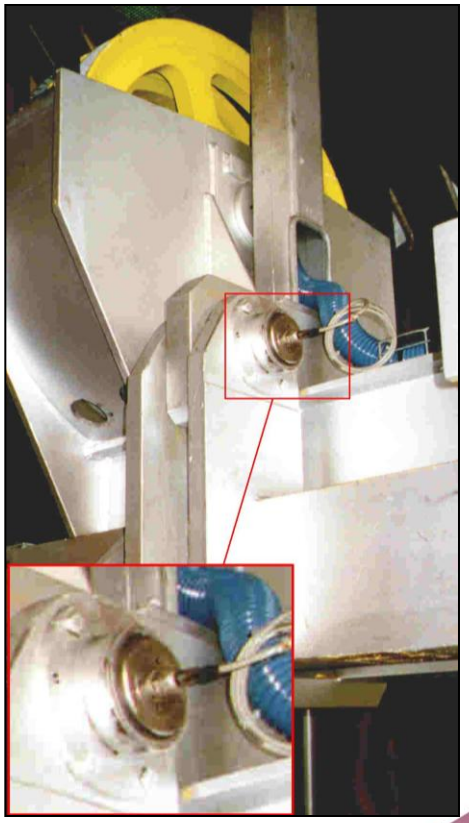
Installation example





Installation example





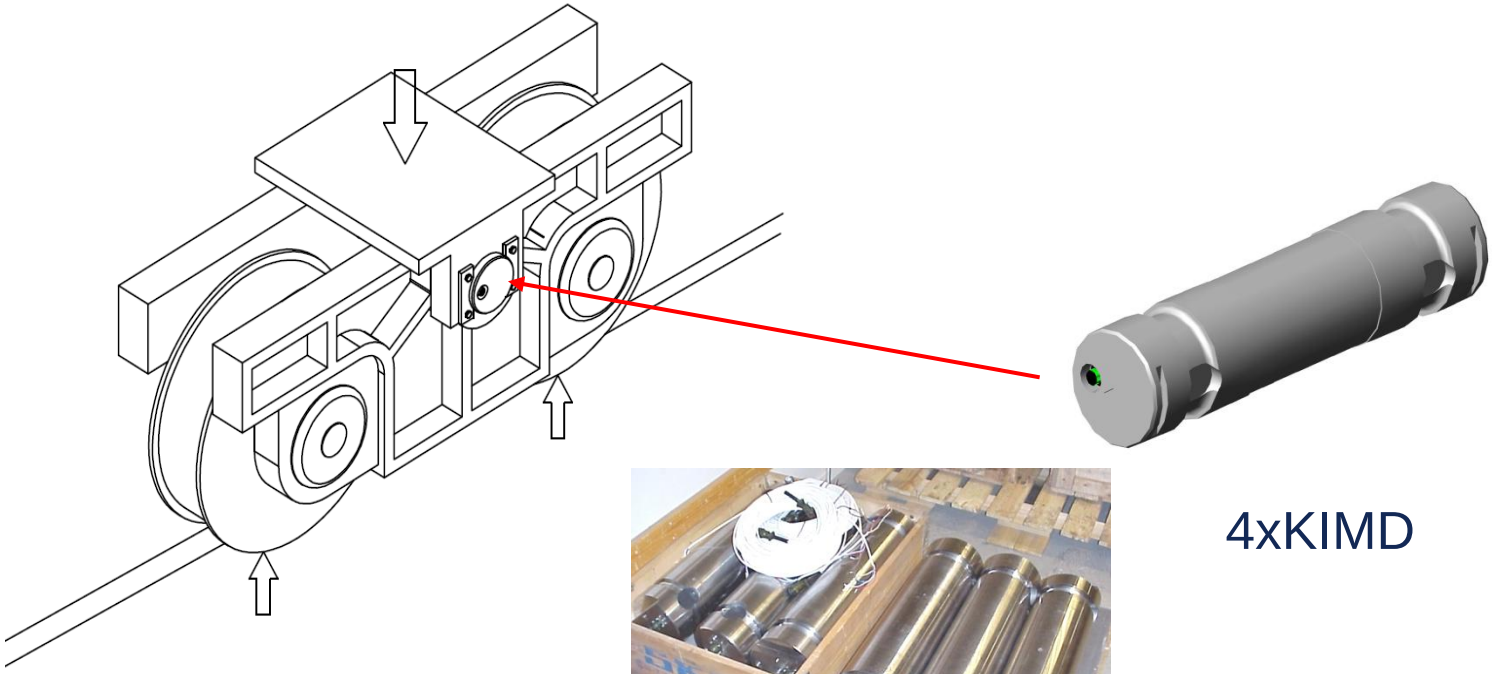
Crane weighing

- Accurate Crane weighing with standard or tailor made load cells:

2xKIMD

Crane weighing

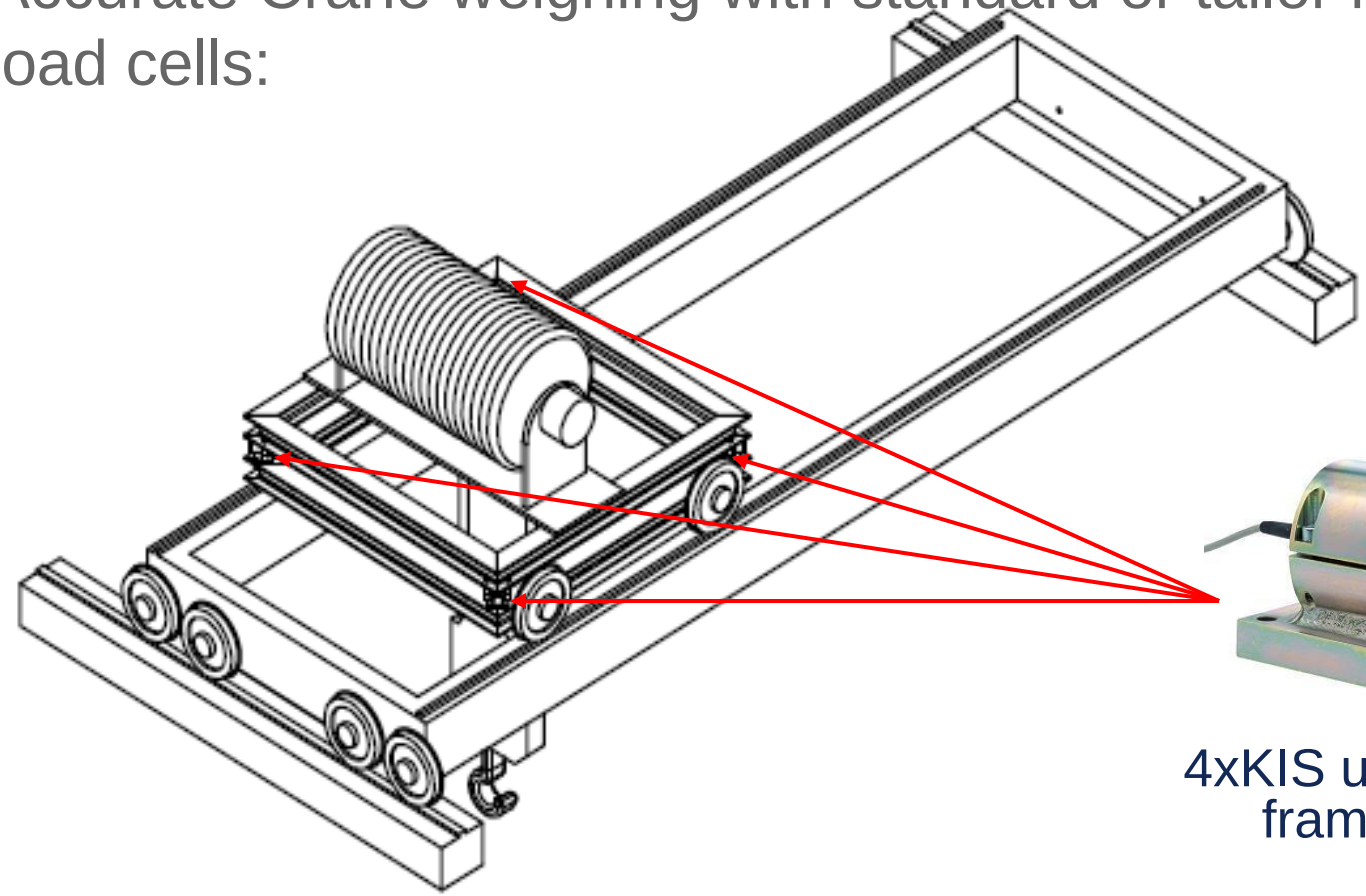
- Accurate Crane weighing with standard or tailor made load cells:



4xKIMD

Crane weighing

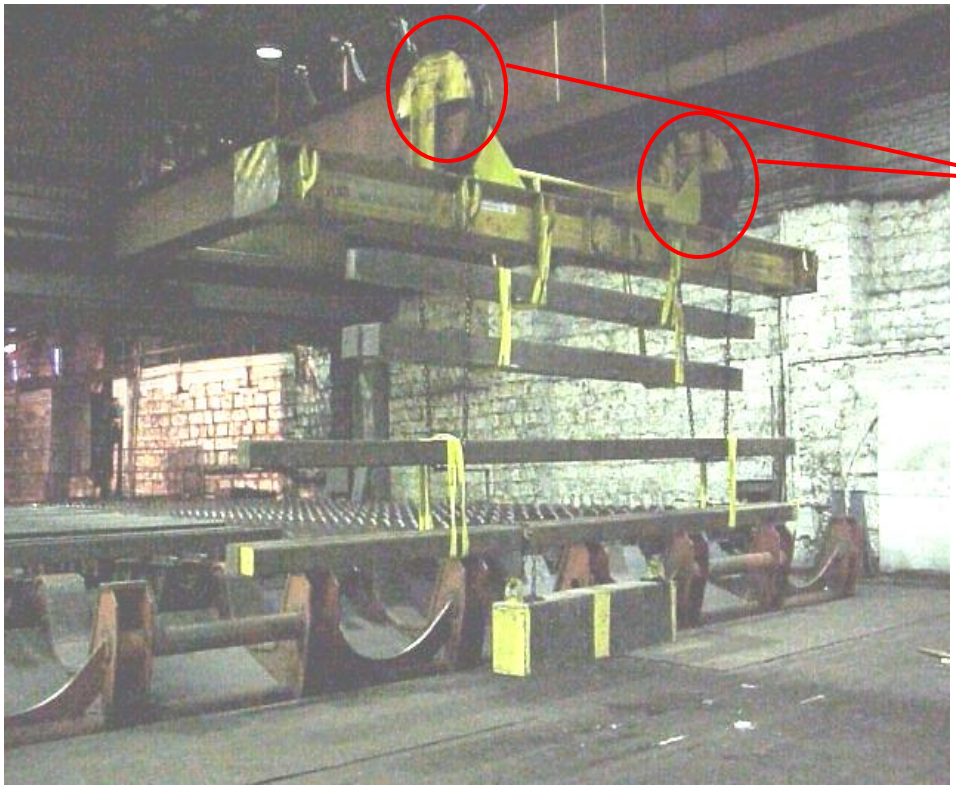
- Accurate Crane weighing with standard or tailor made load cells:

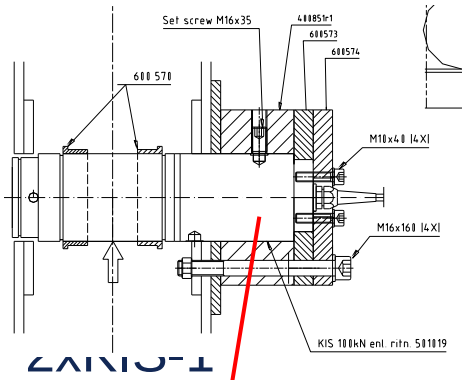


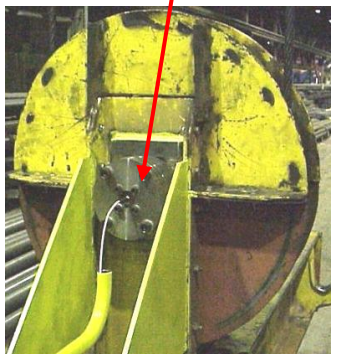
4xKIS under frame

Crane weighing

- Accurate Crane weighing with standard or tailor made load cells:

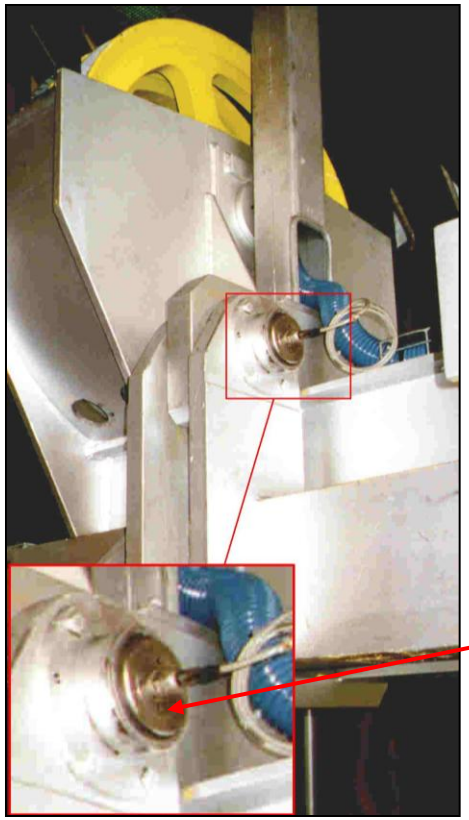






Crane weighing

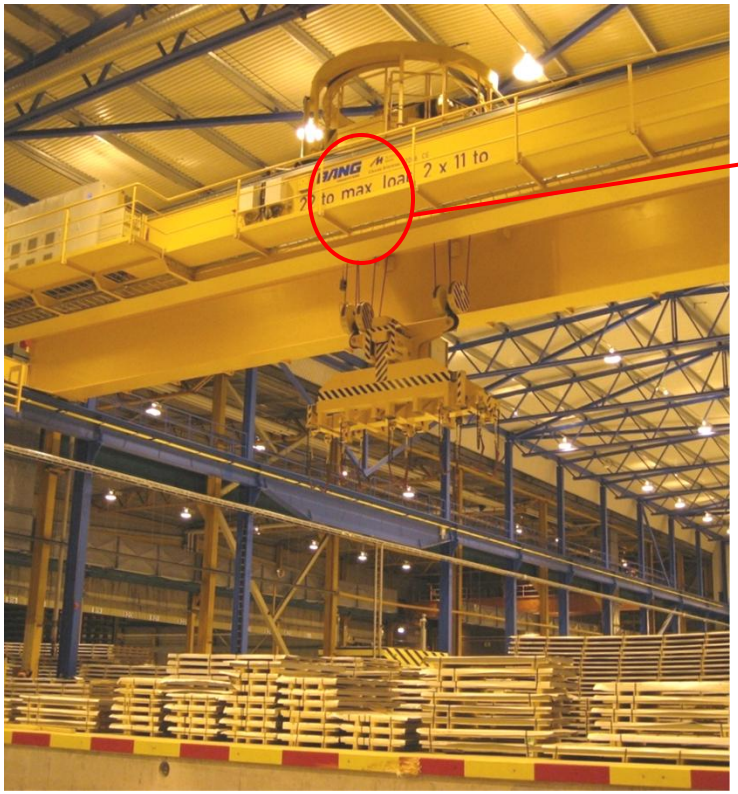
- Accurate Crane weighing with standard or tailor made load cells:



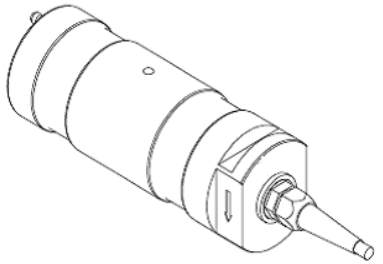
4 x KISD-6R

Crane Load Measurement

- Force measurement on one or several wires. Less accurate load cells.



KOSD special

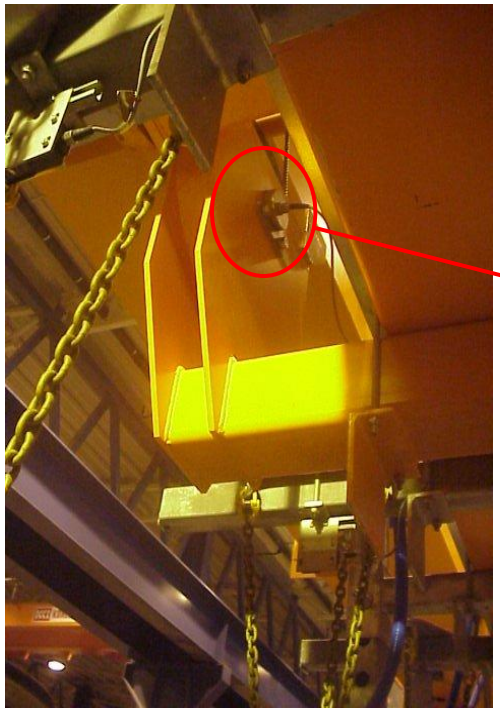


or

S-beam

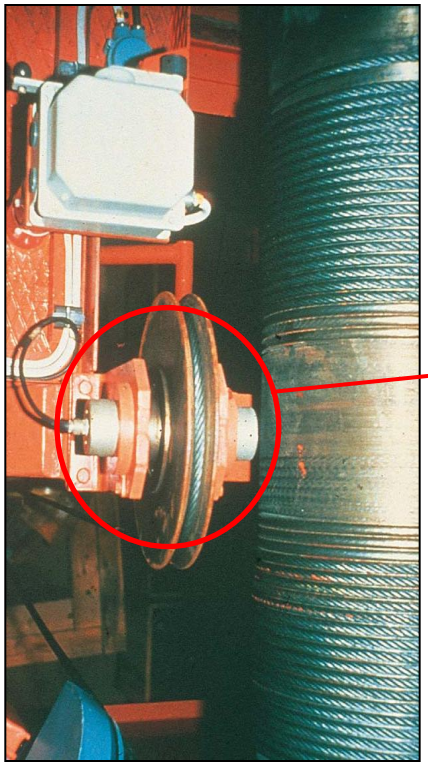
Crane Load Measurement

- Force measurement on one or several wires. Less accurate load cells.



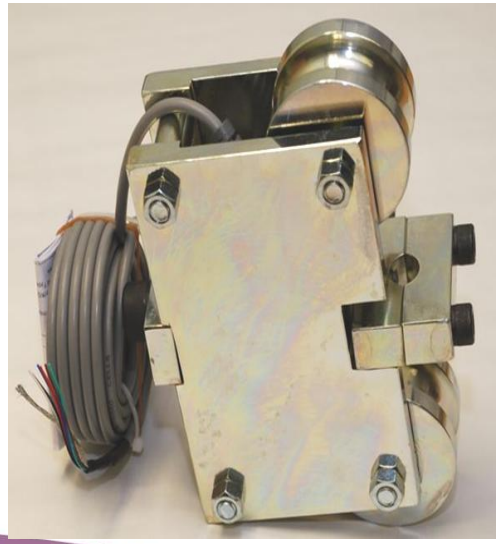
Crane Load Measurement

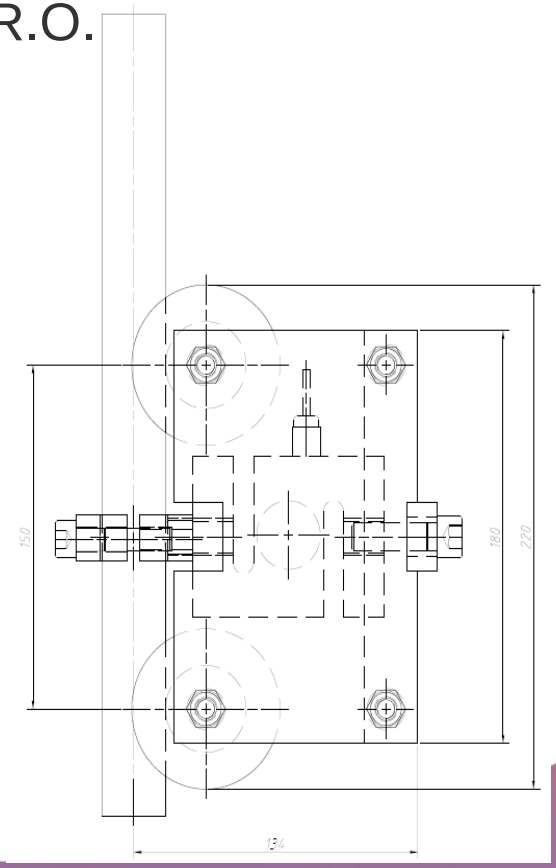
- Force measurement on one or several wires. Less accurate load cells.



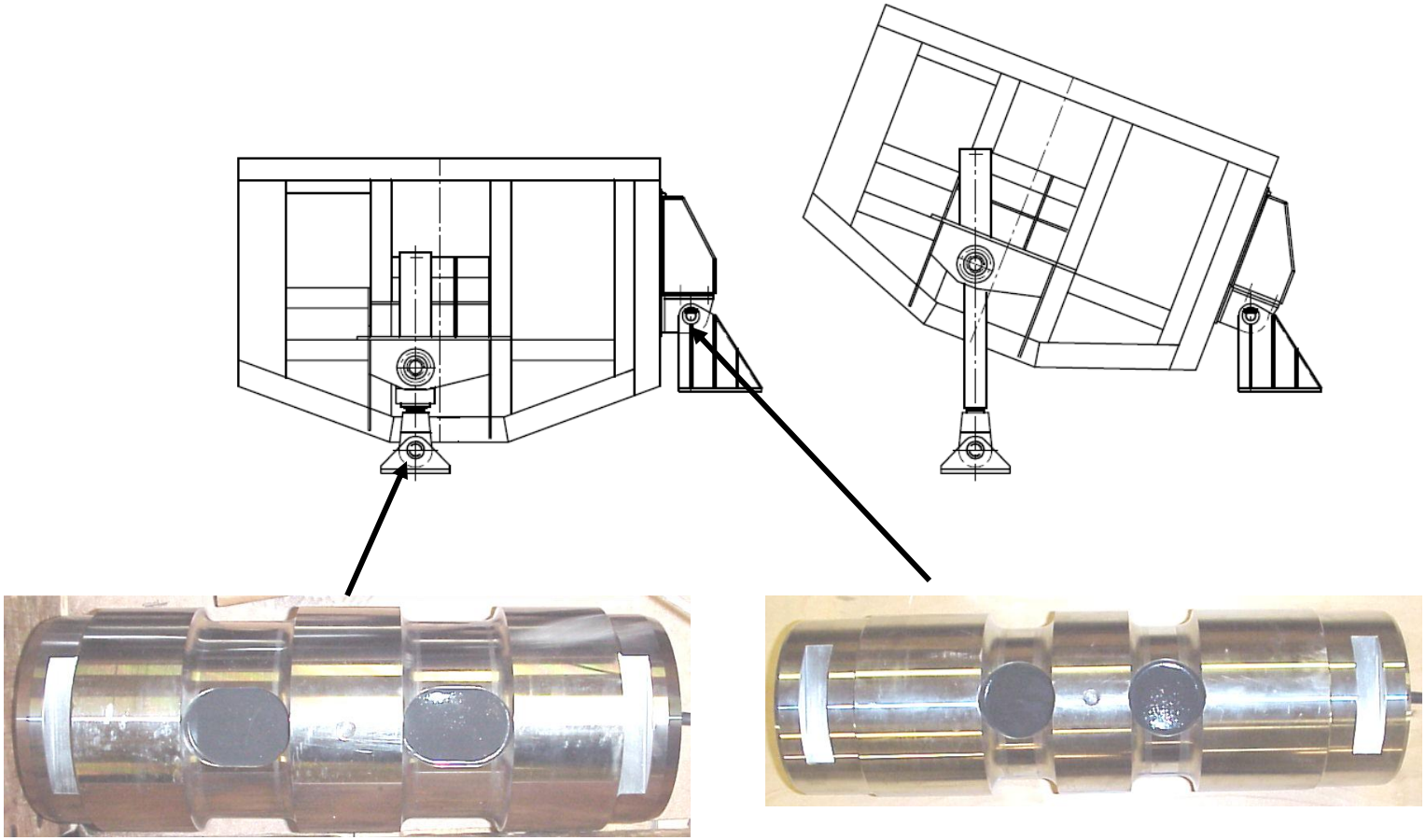
RTT

- Rope Tension Transducer, “clamp on wire” for applications where load cells can´t be installed.
- Accuracy 2 % R.O., Repeatability 1% R.O.
- Wires up to 36 mm diameter
- Dead weight calibration necessary
- Low Cost



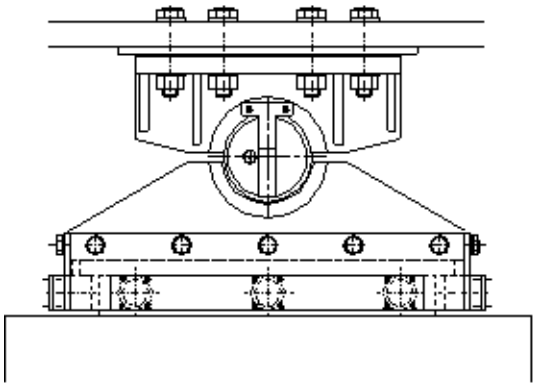


Oven weighing



Oven weighing

Oven weighing



1600 ton weighing
4 x KIMD 4 MN

VISHAY PRECISION GROUP

Nobel Weighing System

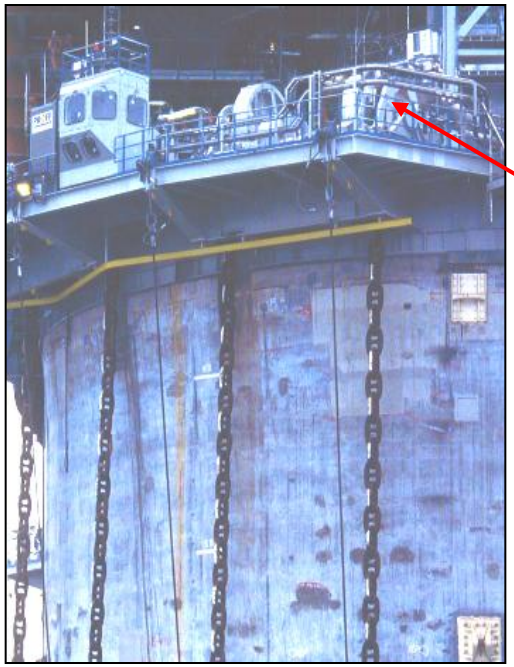
Off shore

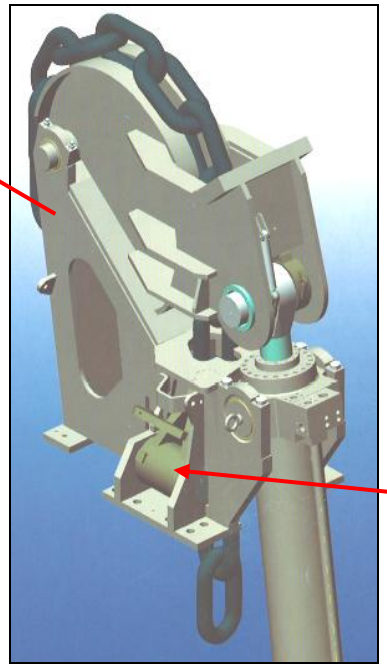
- Cranes – overload protection:

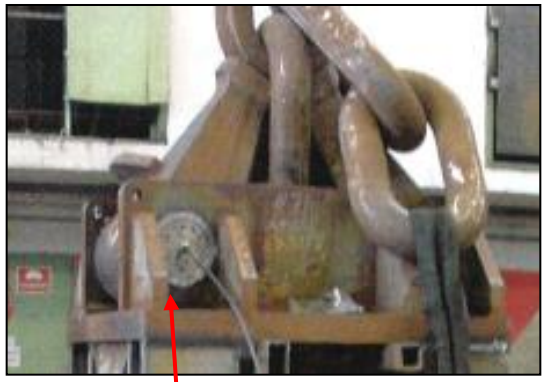
Special KOSD
100 kN up to
7500 kN

Off shore

- Force measurement – Mooring system:

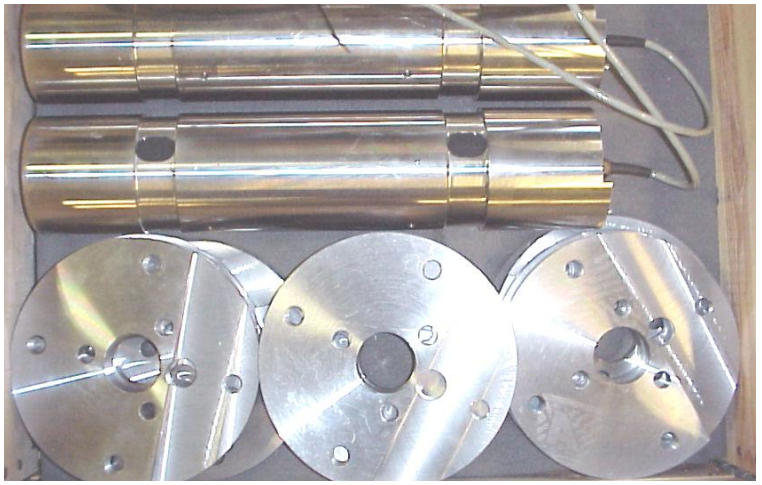


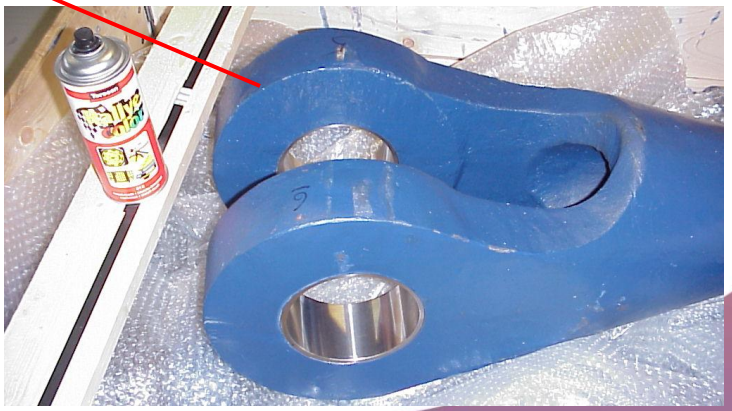




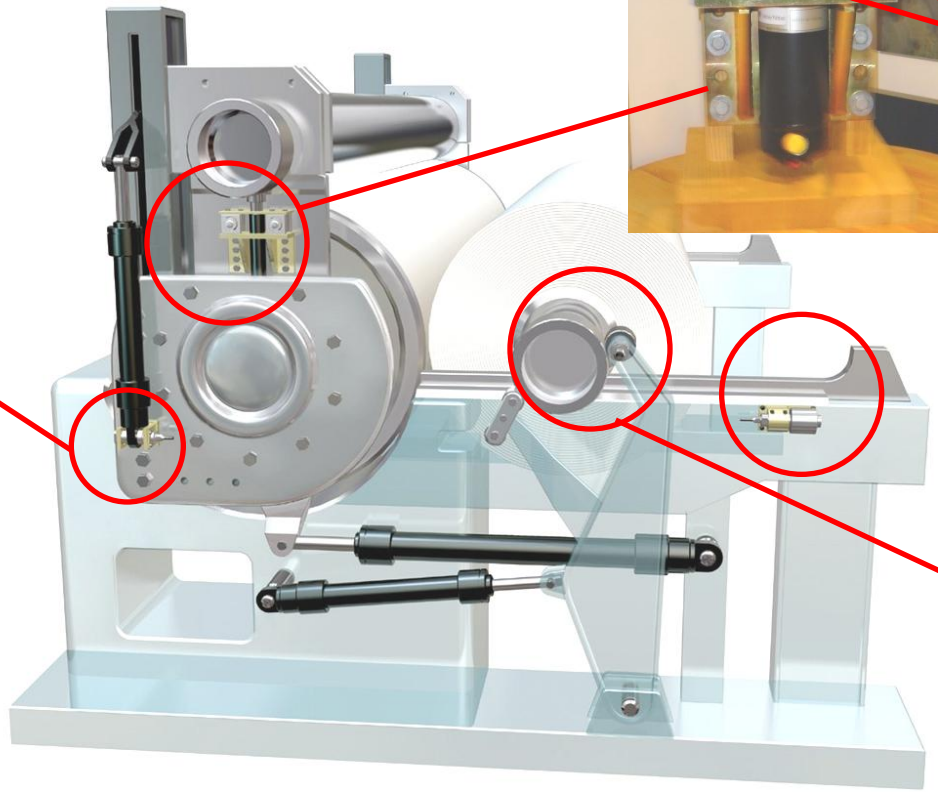
Off shore

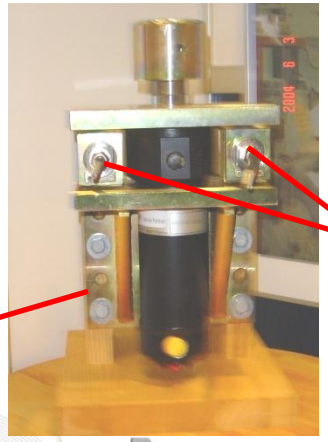
- Drilling rig force measurement:





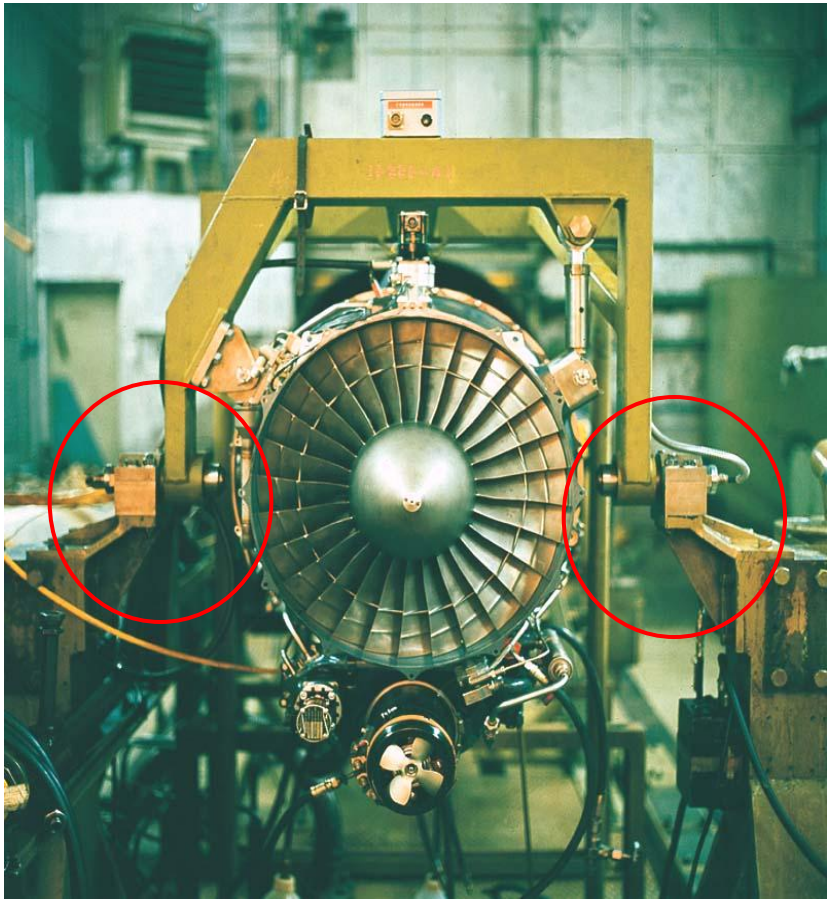
Special load cells ROS





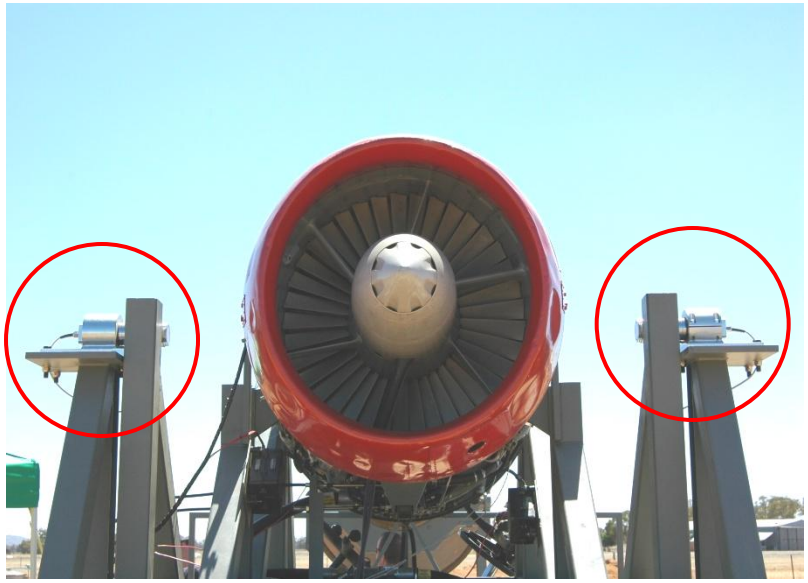
Other Cases

- Jet engine tester 1:



Other Cases

- Jet engine tester 2:



Error and Accuracy

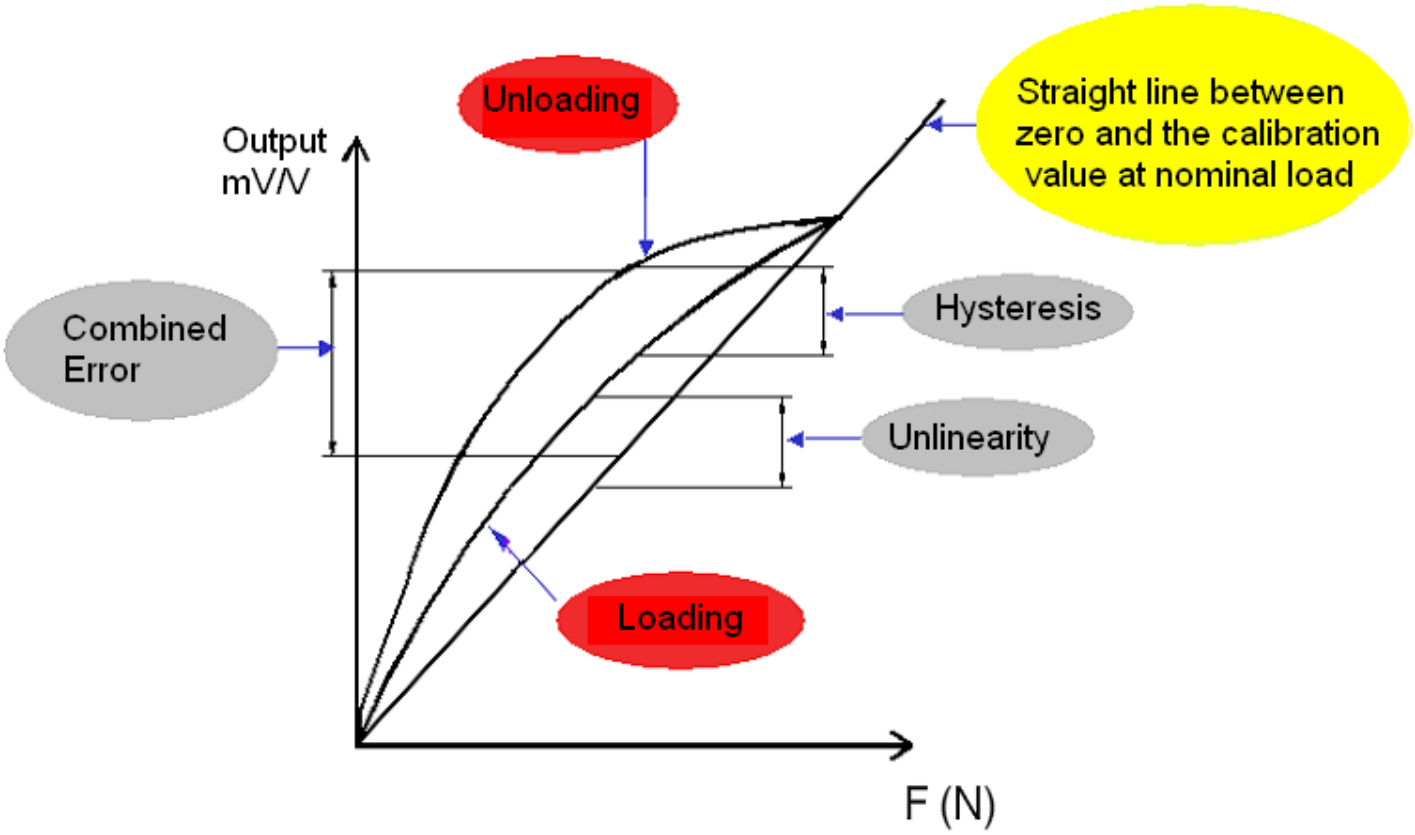
- Error is the difference between the true value and the measured value.

- Error can be divided into two groups, regular and irregular errors.

- The accuracy in a weighing application is dependant of the load cells, the mechanics, the instruments and the calibration method.

Regular errors

Load Cell



DATA AND CALIBRATION SHEET

LOAD CELL **KI8-1** **S/N 56512**

RATED LOAD (R.L.)	50	kN	!	EXCITATION VOLTAGE. RECOMMENDED	10 V AC OR DC
			!	EXCITATION VOLTAGE. MAXIMUM	18 V AC OR DC
OVERLOAD. SAFE	100	% R.L.	!		
OVERLOAD. ULTIMATE	200	% R.L.	!	INPUT RESISTANCE 350 +/- 3 OHMS INCL. STANDARD CABLE	
			!	OUTPUT RESISTANCE 349.9 OHMS INCL. STANDARD CABLE	
SIDE LOAD. SAFE	100	% R.L.	!		
SIDE LOAD. ULTIMATE	200	% R.L.	!	TEMPERATURE RANGE -40 TO +100 DEGREES C	

ELECTRICAL CONNECTION	SHIELDED 4-CONDUCTOR CABLE		!	TEMPERATURE EFFECT (-10 TO +50 DEGREES C)	
EXCITATION POSITIVE:	RED OR RED STRIPE ON GREEN		!		
EXCITATION NEGATIVE:	BLACK		!	ON OUTPUT	0.0015 % OF OUTPUT PER DEG. C
SIGNAL POSITIVE:	GREEN OR GREEN STRIPE ON WHITE		!		
SIGNAL NEGATIVE:	WHITE OR WHITE STRIPE ON RED		!	ON ZERO BALANCE	0.003 % OF R.O. PER DEG. C

RATED OUTPUT (R.O.) (TOLERANCE 0.1 %)		**2.0392 mV/V**
NONLINEARITY (BEST FIT THROUGH ZERO)	+/-	0.012 % R.O.
ZERO BALANCE		+0.3 % R.O.
CREEP 5 MINUTES		+0.003 % R.O.

CALIBRATION VALUES (TOLERANCE 0.1 %)SHUNT RESISTOR CONNECTED BETWEEN 'EXCITATION NEGATIVE 'AND 'SIGNAL NEGATIVE

40 KOHMS CORRESPOND TO **51.471 kN**

80 KOHMS CORRESPOND TO **25.791 kN**

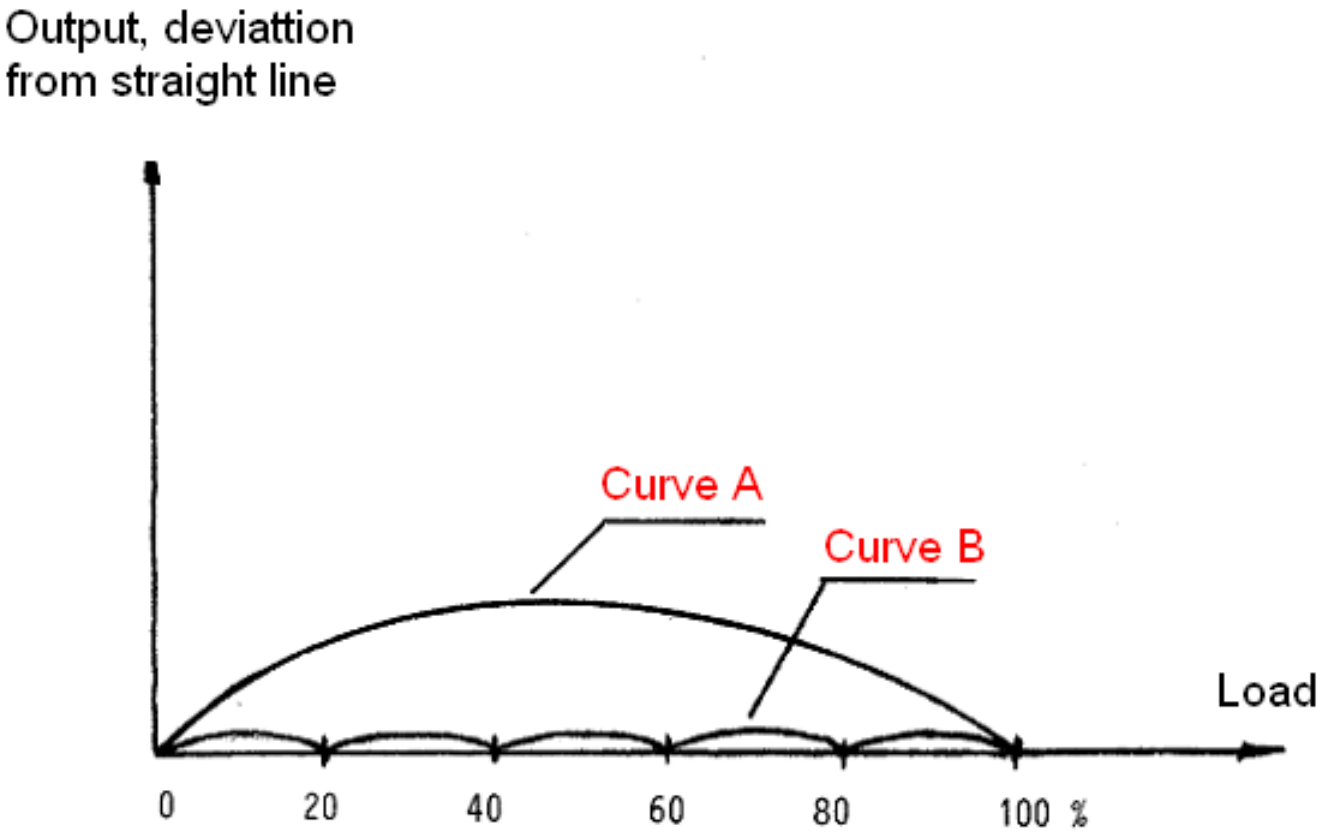
THE VALUES INDICATED FOR OUTPUT VOLTAGE AND CALIBRATION VALUES ARE APPLICABLE AT OPEN CIRCUIT WITHOUT EXTERNAL BALANCING RESISTORS AND WITH A CONNECTING CABLE OF STANDARD LENGTH.

NOBEL ELEKTRONIK AB
S-691 27 KARLSKOGA

KARLSKOGA 88-03-01

STGP

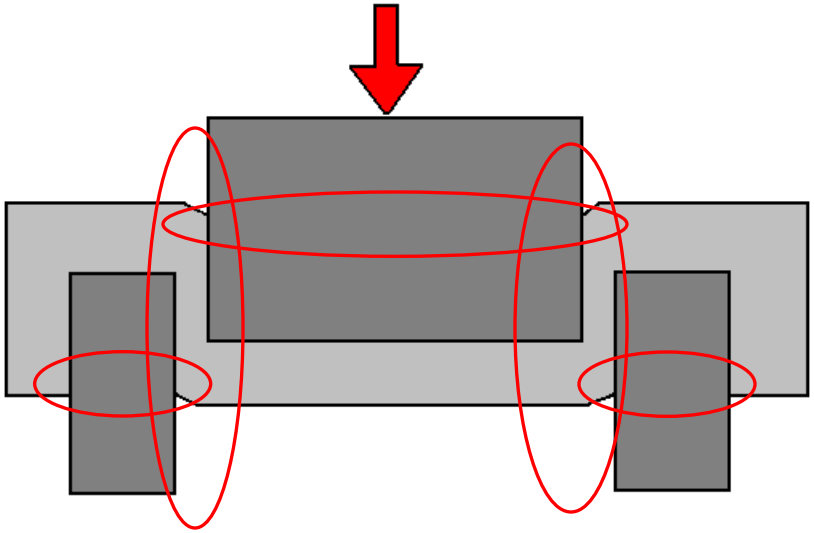
Linearization



- For load cells with small hysteresis and/or when used only for weighing in, can linearization increase the accuracy of the application.

Non repeatable errors

- Inbuilt frictions causes non repeatable errors.

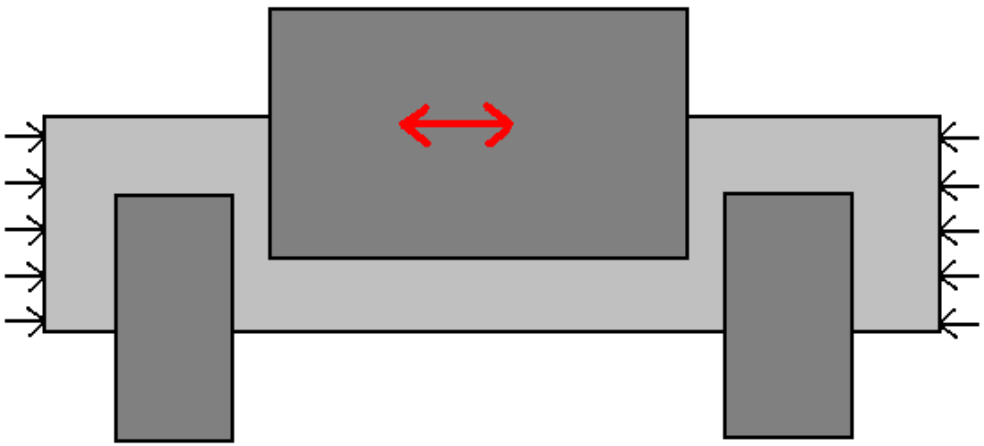


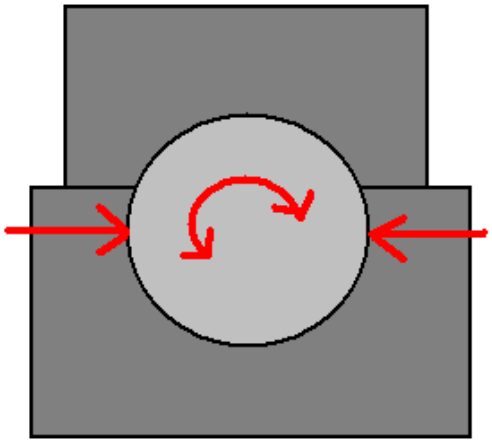
1 . Frictions in support – less problem with stiff load cells

2 . Frictions between support

Non repeatable errors

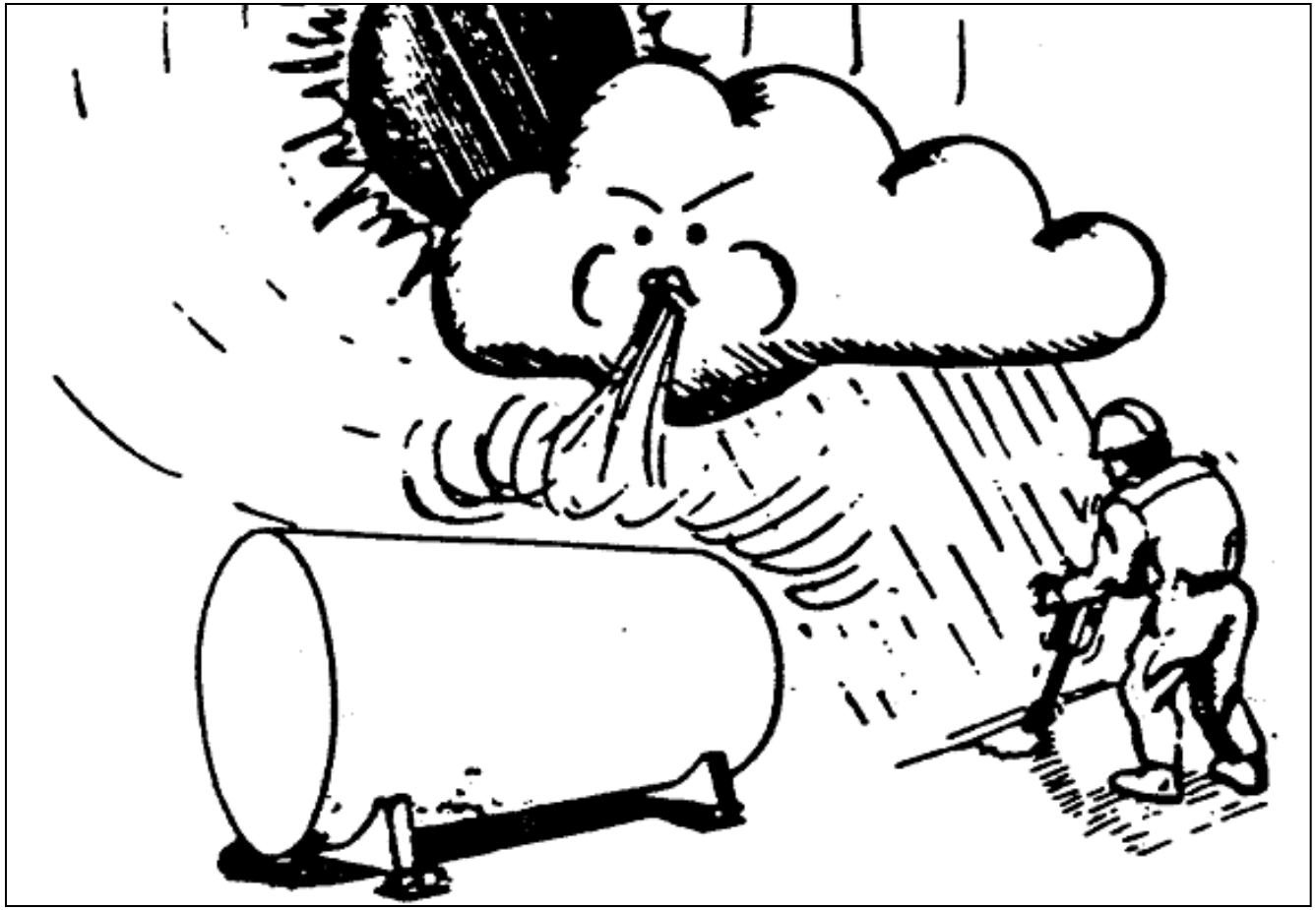
- Other disturbing force can come from load case, mechanics arround load cell and thermal expansion.





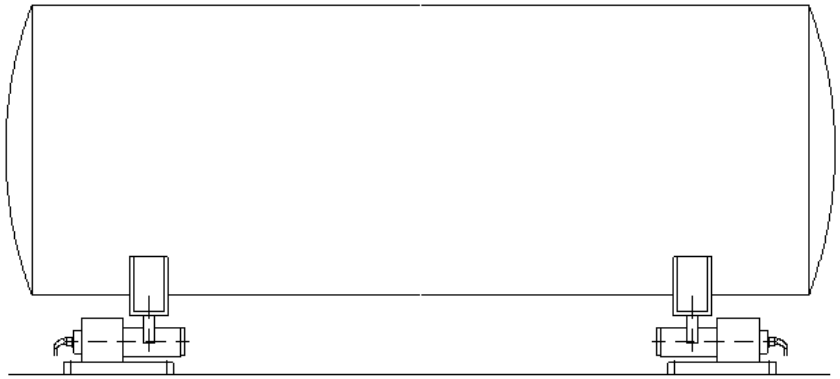
- Shear stress load cells are often less sensitive to this. Other have to be reduced in constructing or taken into accuracy calculations.

Irregular errors



Accuracy in weighing

- Full set of load cells for best accuracy. Distribution of material uncritical.

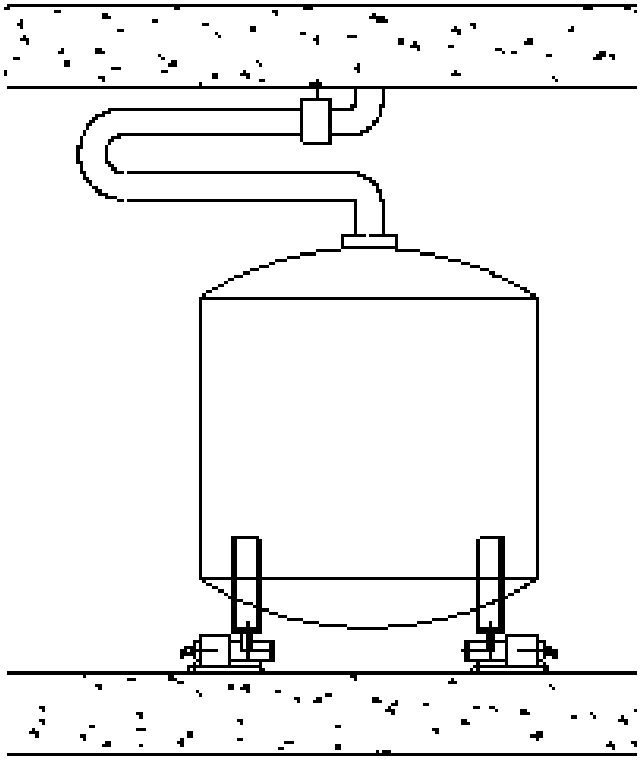


- Partly supported by load cells, do not expect better accuracy than 0,5%. Requires evenly distributed material.

Negative effect

Mechanical connections

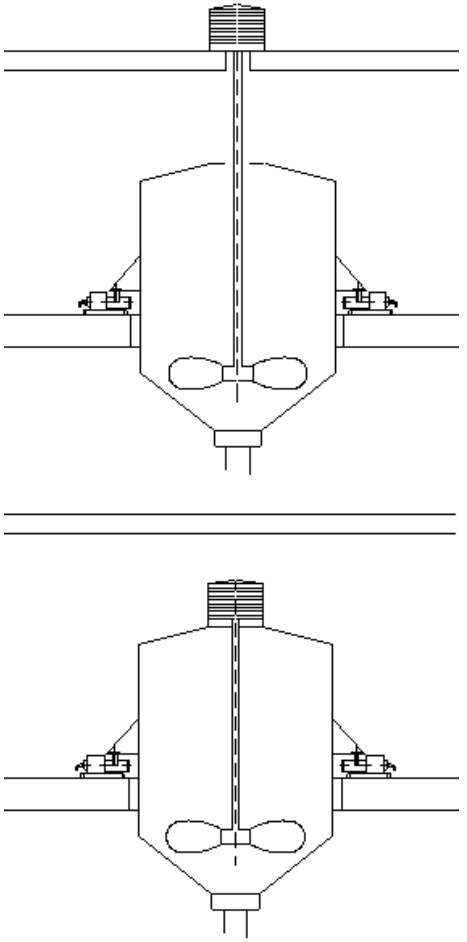
- Calculated the force that is shunted by the connections.
- Use flexible connections at need.
- Full set of load cells.



Negative effect

Agitator

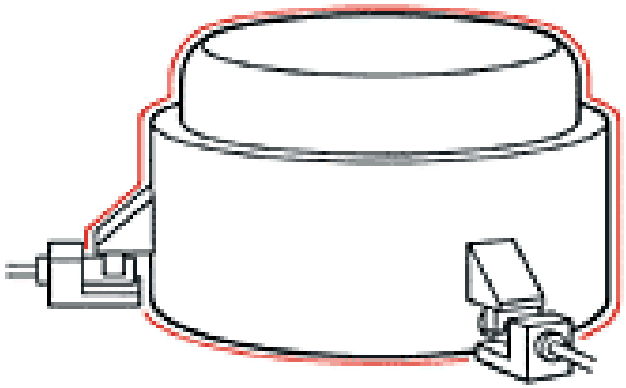
- Choose load cells that are insensitive to side loads.
- Choose instruments with filtering options.
- Make sure that the agitator is connected to the vessel that should be weighed, so that propeller effect is avoided.



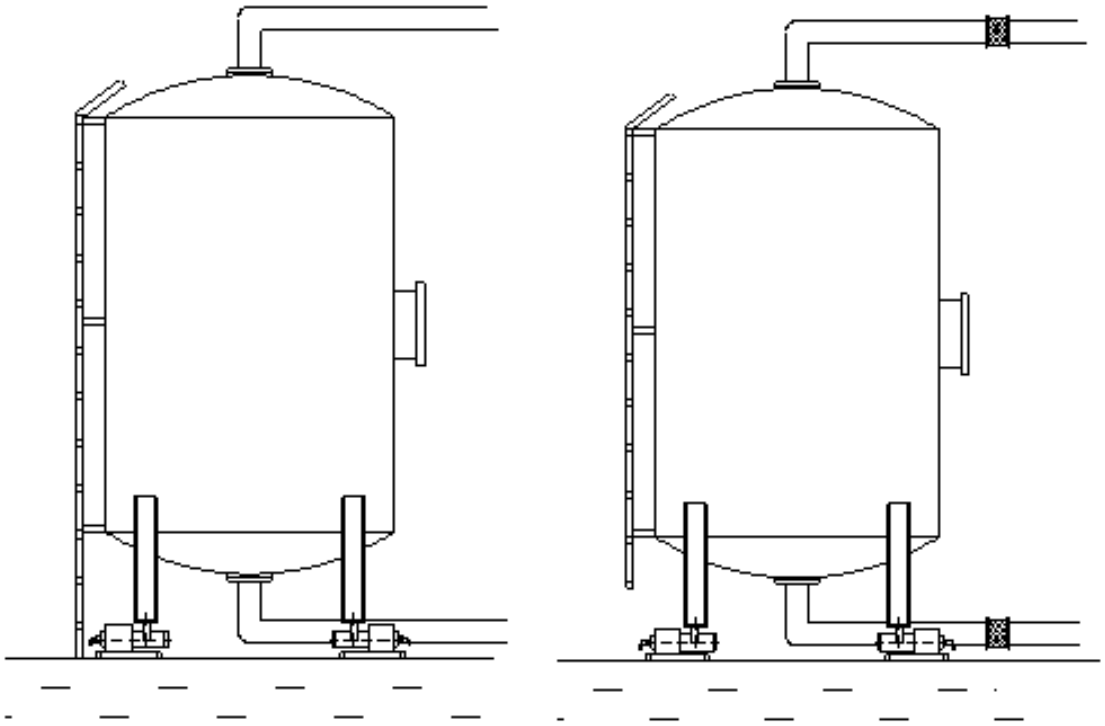
Negative effect

Temperature fluctuations

- Choose highly temperature compensated load cells.
- Do not mount load cells in a way that does not allow for material expansion.
- Choose load cells that are insensitive to side loads.

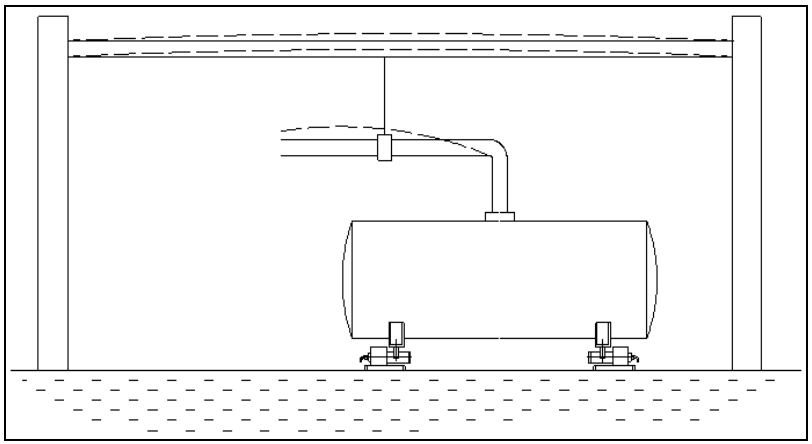


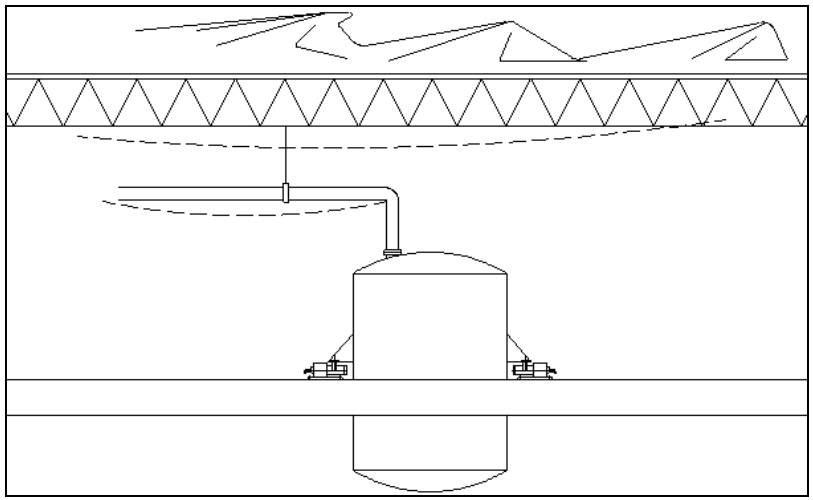
To think about

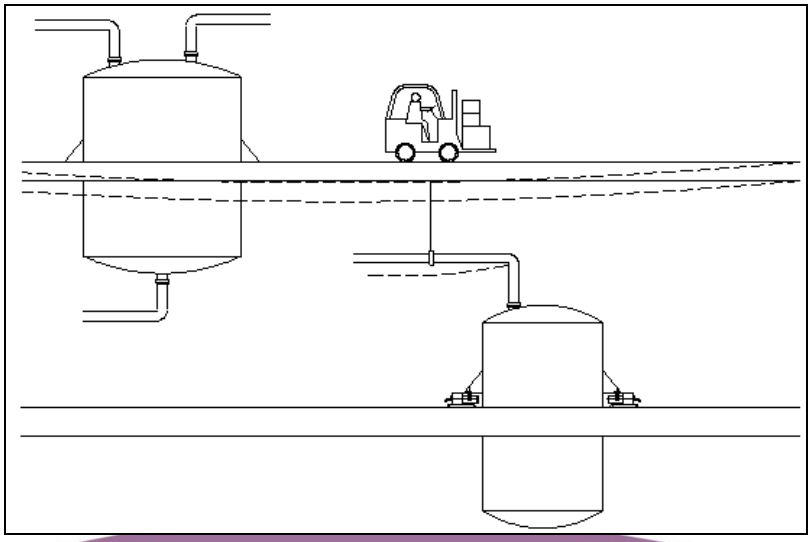


- Force is shunt by ladder and rigid connections – connect ladder to vessel and use flexible connections.

To think about

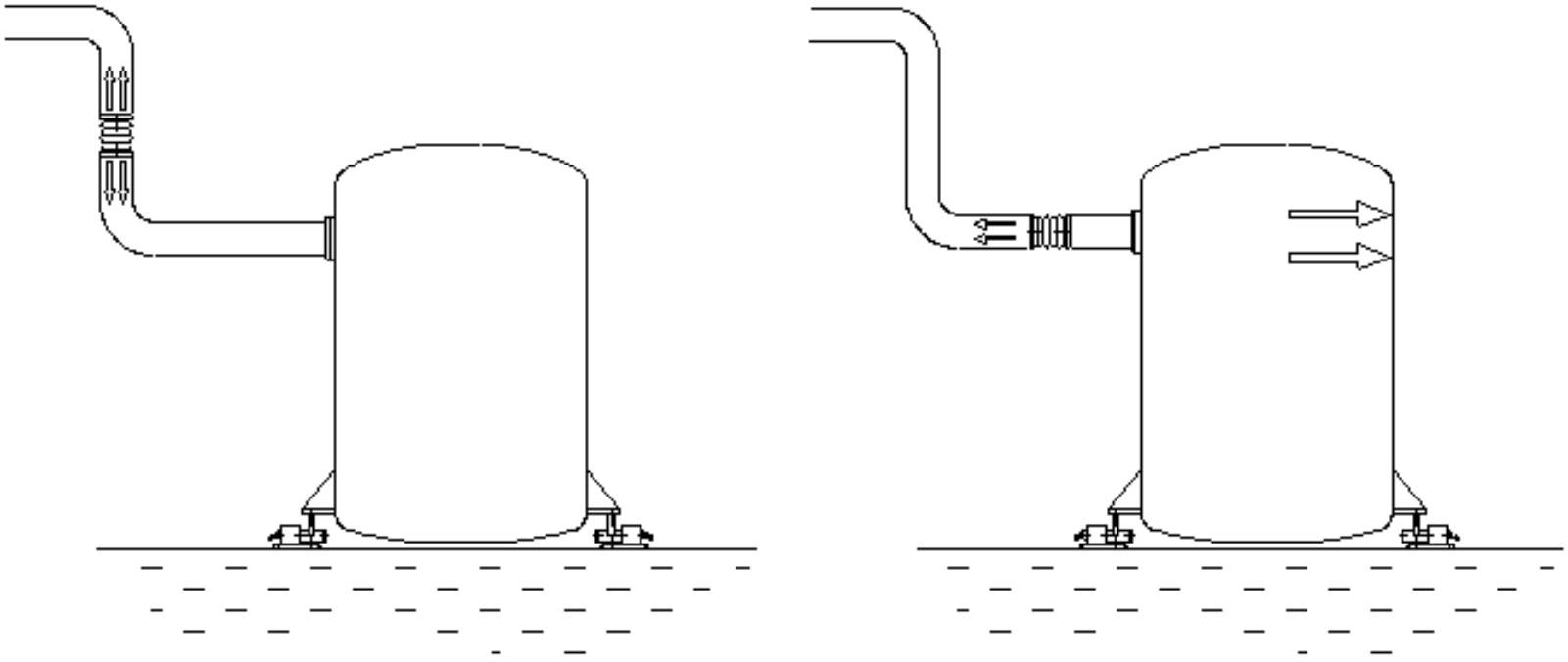






- Place weighed vessel and connections so that these are not effected by structural motions.

To think about



•High pressure in inlet – Assure that force is applied horizontally and use full set of load cells.

Summary

- The mechanical arrangement arround the load cell is more likely to affect the result and repeatability than the load cell it self.
- Unrepeatable errors can not be compensated with good result.
- Full set of highly temperature compensated load cells is necessary for the high accuracy demanding applications.

Error investigation

- Mechanical Errors
- Electrical connections
- Load cell errors

Mechanical Errors

- Inbuilt tensions and frictions – often seen as non repeating result and shifting zero. Typical reasons; twisted yoke, mechanical surface between yoke and bracket in contact.

- Force shunt - electrical connections, pipes etc removing load/force from cell. Can be repeating or not.

- Not correctly orientated load cell - load cell rotated in bracket, floor or foundation not stiff enough.

Electrical connection

- Correct electrical installation, different cables have different color code, our standard PVC:

Exc +	-	Red stripe on White
Exc -	-	Black
Sign +	-	White stripe on Green
Sign -	-	Green stripe on Red

- The load cell is calibrated with full cable length, four wire and should not be cut. Always use six-wire from junction box.

- Cables should not be close to high electrical fields.

Load cell errors

- Measure input and output resistance – no loose wires in load cell.
- Measure zero balance – no overloaded load cell.
- Insulation (e.g. 50 V Megger) – water ingress?
- Loose soldering/strain gauge – fluctuating signal to large extent. Very seldom the strain gauge.

Use info from calibration data sheet

DATA AND CALIBRATION SHEET

LOAD CELL KIB-1 S/N 56512

RATED LOAD (R.L.)	50	kN	!	EXCITATION VOLTAGE. RECOMMENDED	10 V AC OR DC
			!	EXCITATION VOLTAGE. MAXIMUM	18 V AC OR DC
OVERLOAD. SAFE	100	% R.L.	!		
OVERLOAD. ULTIMATE	200	% R.L.	!	INPUT RESISTANCE 350 +/- 3 OHMS INCL. STANDARD CABLE	
			!	OUTPUT RESISTANCE 349.9 OHMS INCL. STANDARD CABLE	
SIDE LOAD. SAFE	100	% R.L.	!		
SIDE LOAD. ULTIMATE	200	% R.L.	!	TEMPERATURE RANGE -40 TO +100 DEGREES C	

ELECTRICAL CONNECTION	SHIELDED 4-CONDUCTOR CABLE	!	TEMPERATURE EFFECT (-10 TO +50 DEGREES C)
EXCITATION POSITIVE:	RED OR RED STRIPE ON GREEN	!	
EXCITATION NEGATIVE:	BLACK	!	ON OUTPUT 0.0015 % OF OUTPUT PER DEG. C
SIGNAL POSITIVE:	GREEN OR GREEN STRIPE ON WHITE	!	
SIGNAL NEGATIVE:	WHITE OR WHITE STRIPE ON RED	!	ON ZERO BALANCE 0.003 % OF R.O. PER DEG. C

RATED OUTPUT (R.O.) (TOLERANCE 0.1 %)		**2.0392 mV/V**
NONLINEARITY (BEST FIT THROUGH ZERO)	+/-	0.012 % R.O.
ZERO BALANCE		+0.3 % R.O.
CREEP 5 MINUTES		+0.003 % R.O.

CALIBRATION VALUES (TOLERANCE 0.1 %)SHUNT RESISTOR CONNECTED BETWEEN 'EXCITATION NEGATIVE 'AND 'SIGNAL NEGATIVE

40 KOHMS CORRESPOND TO **51.471 kN**

80 KOHMS CORRESPOND TO **25.791 kN**

THE VALUES INDICATED FOR OUTPUT VOLTAGE AND CALIBRATION VALUES ARE APPLICABLE AT OPEN CIRCUIT WITHOUT EXTERNAL BALANCING RESISTORS AND WITH A CONNECTING CABLE OF STANDARD LENGTH.

NOBEL ELEKTRONIK AB
S-691 27 KARLSKOGA

KARLSKOGA 88-03-01

STGF

Load cell overload

- Load cells are defined as follows:

  Nominal load (e.g. 100 kN)

  Safe load 150 or 200% (150 or 200 kN)

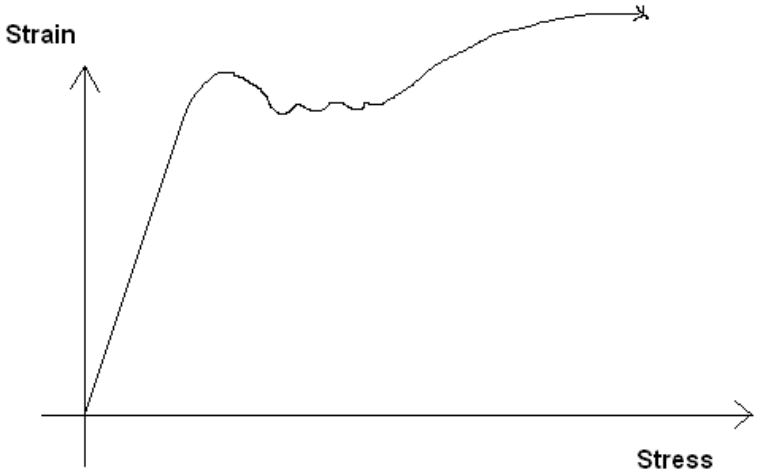
  Ultimate load 200 or 300% (200 or 300 kN)

  Break load

- Safe and ultimate load refers to the function of the cell. < Safe load should mean no zero shift, < Ultimate means zero shift, > Ultimate load mens load cell broken.

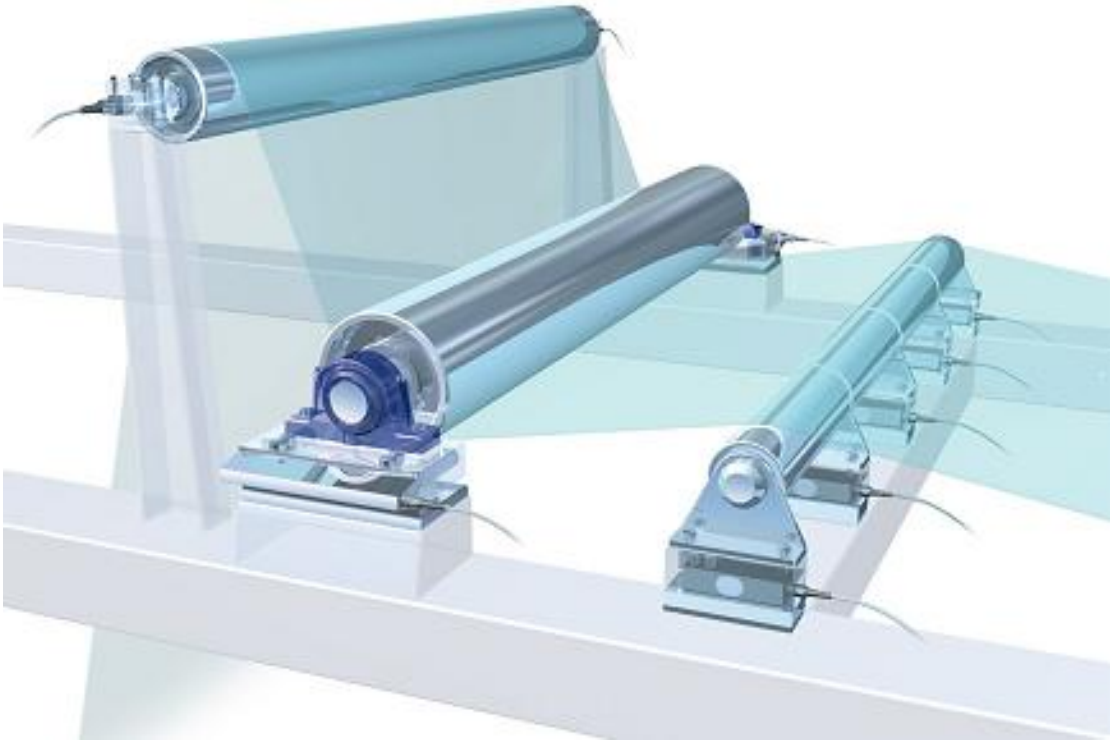
Load cell overload

- All is depending on the physical caracteristics of the load cell material.



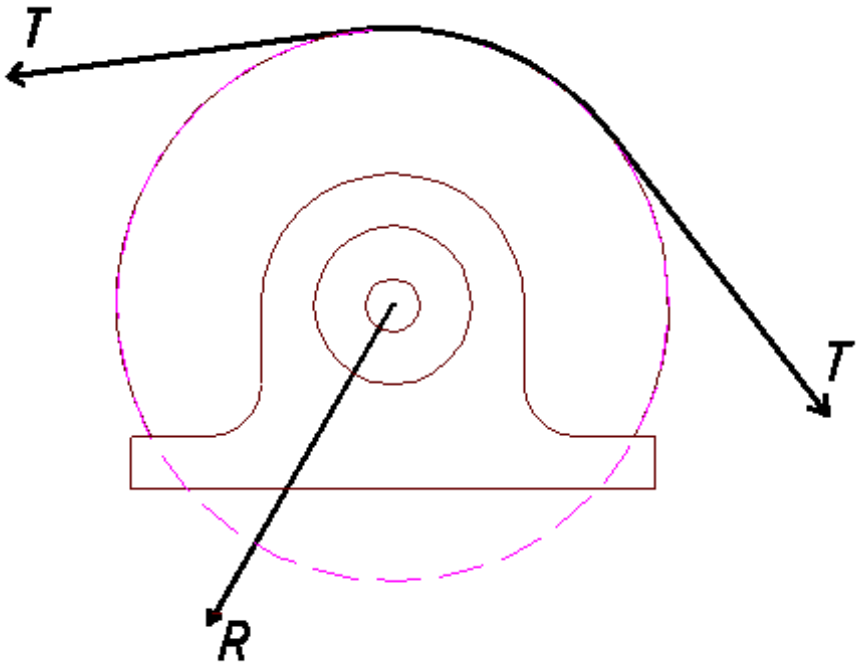
- Above ultimate load, the adhesive can not follow the steel and zero shift is to great.

Web Tension



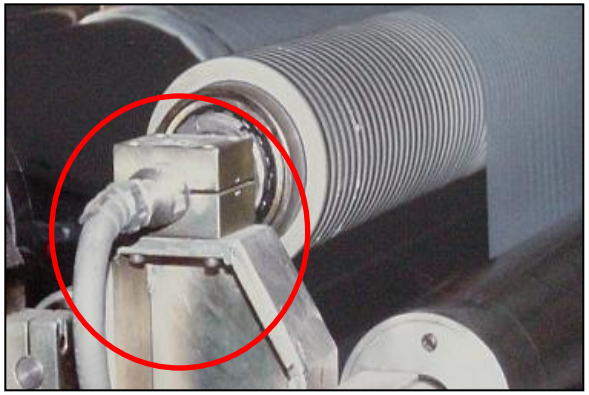
Web tension measurment

Resultant force in neutral axis



KIS as a shaft

- Capacities: 1, 2, 5, 10, 20, 30, 50, 100, 200, 300 and 500 kN
- Measuring range: 1-100% of nominal range
- Measuring element ideally placed in neutral axis
- Possible to turn transducer in resultant force direction
- High accuracy, highly temperature compensated
- Needs very small space, but roller must have integrated bearing



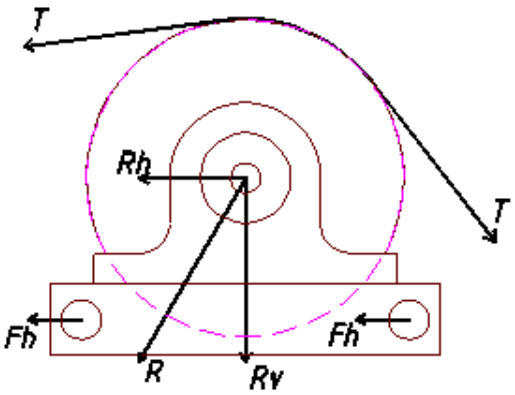
GLT and LTT

- Low Web Tension, capacity 0,09 to 2,23 kN.
- Easy installation.
- Low built, stainless steel, high accuracy and temp. compensated.
- Possible to turn transducers in resultant force direction.

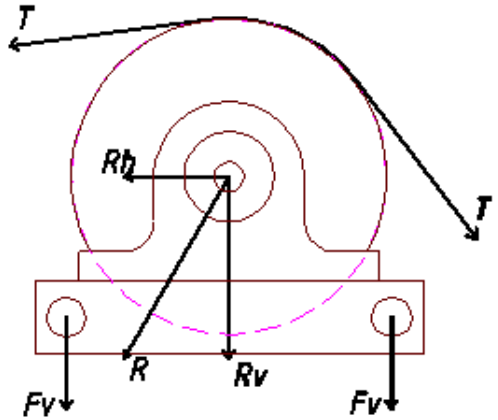
GLT

LTT

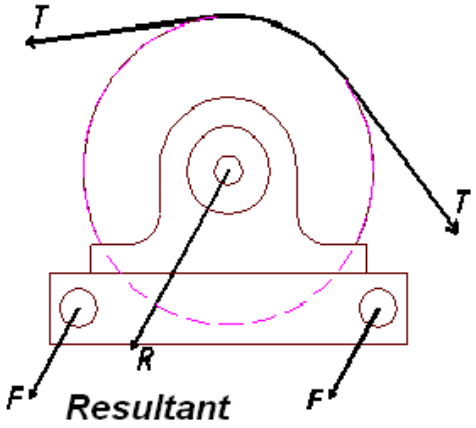
Web Tension Measurement



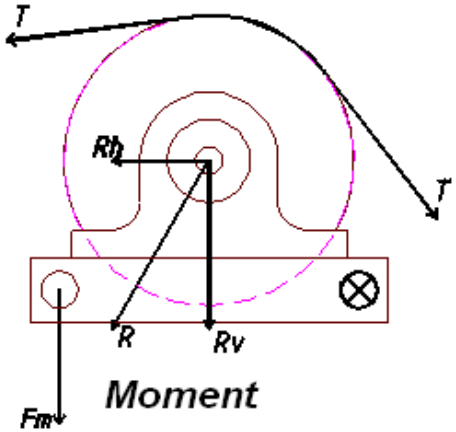
Horizontal Component



Vertical Component

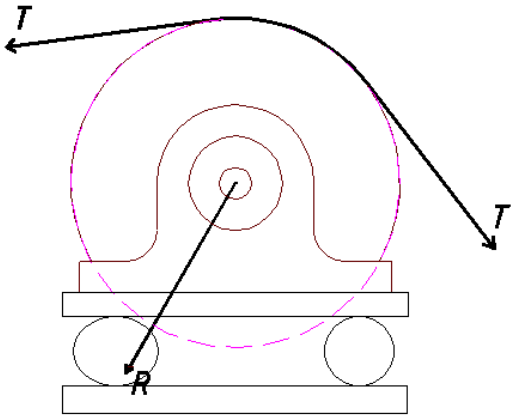


Resultant

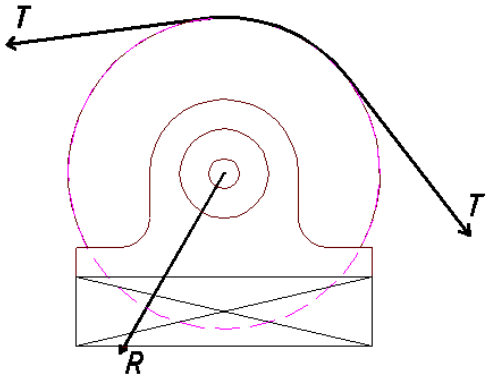


Moment

Mechanical arrangement or complete unit



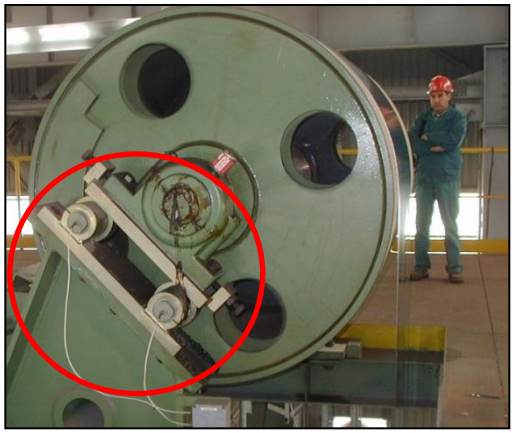
FMU-1, FMU-5, PST-2



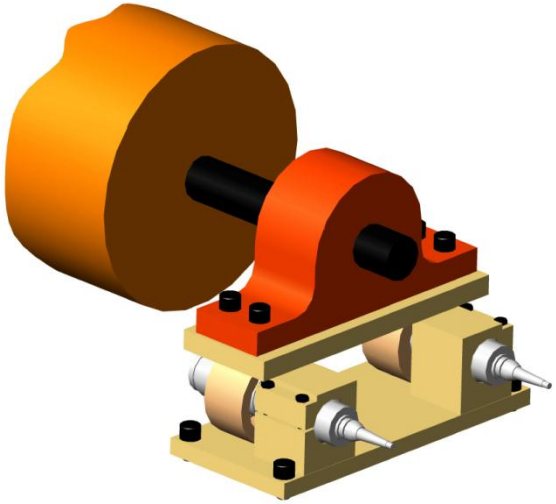
KIP-1, HTU

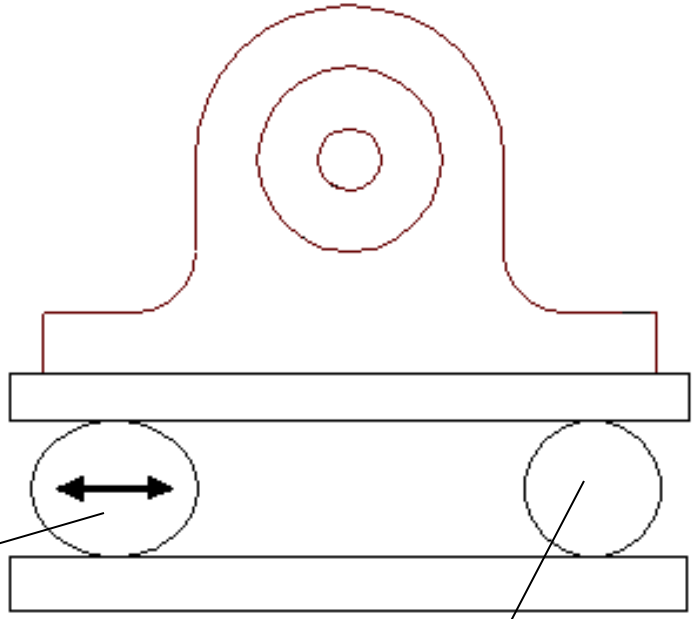
FMU-1

- Capacities: 2, 4, 10, 20, 40, 60, 100 and 200 kN
- Measuring 1-100% of nominal range
- Easy to customize
- High accuracy, highly temperature compensated transducers
- Possible to turn transducers in resultant force direction
- Possible to manufacture in stainless steel



FMU construction

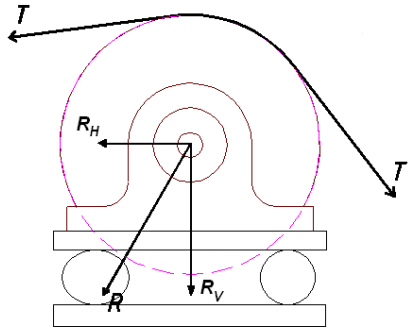


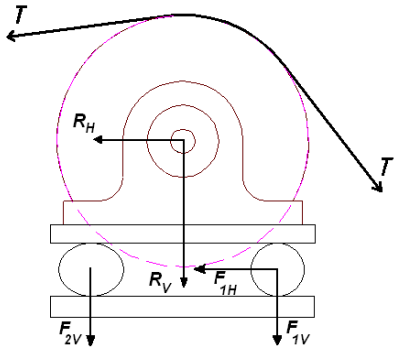


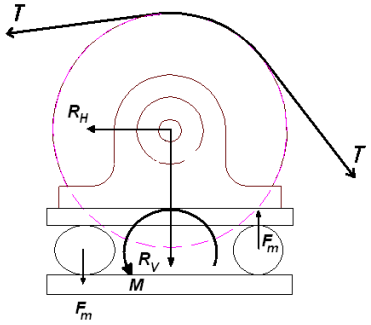
Load cell in flexible hole, allows thermal expansion

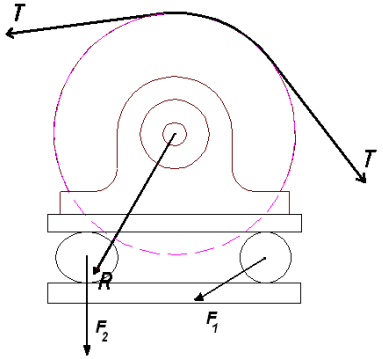
Load cell in fixed hole

Forces on the FMU







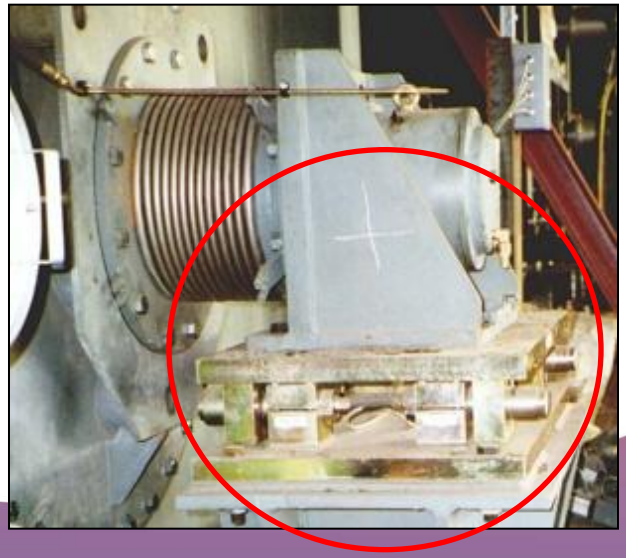


FMU-5

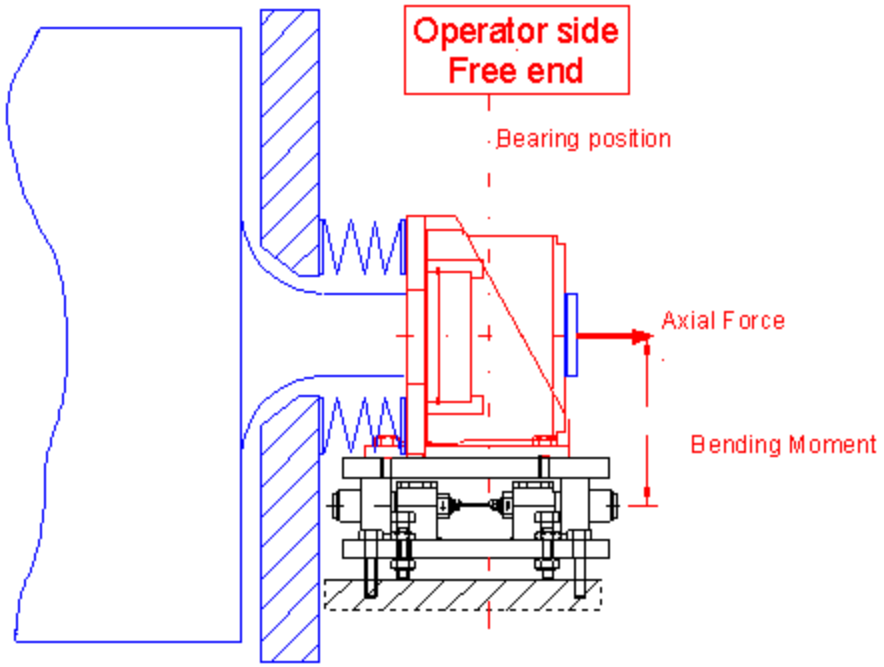
- Capacities: 100, 200, 400, 800 kN (and 2 MN)
- Measuring 1-100% of nominal range
- Easy to customize
- High accuracy, temperature compensated transducers
- Possible to turn transducers in resultant force direction
- Possible to manufacture in stainless steel

PST-2

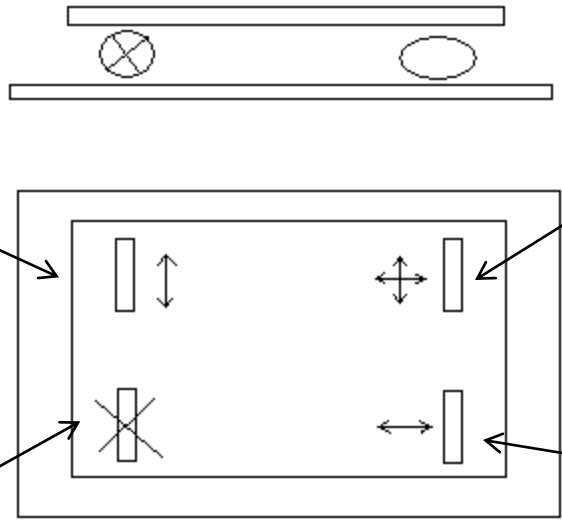
- Measuring range 20, 40, 80 and 120 kN (more on demand)
- To use when high axial thermal expansion of roller.
- Easy to customize
- High accuracy, temperature compensated transducers
- Possible to turn transducers in resultant force direction
- Possible to manufacture in stainless steel
- Less costly than competitor solution and less spare parts



PST-2

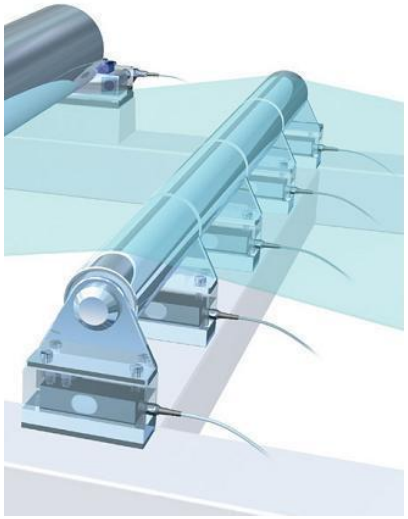

Operator side
Free end
Bearing position
Axial Force
Bending Moment

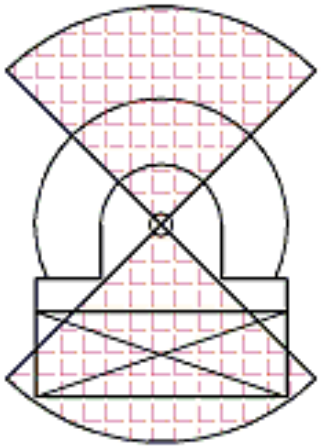
PST-2 design


Flexible in one direction
Flexible in two directions
Fixed
Flexible in one direction

KIP-1

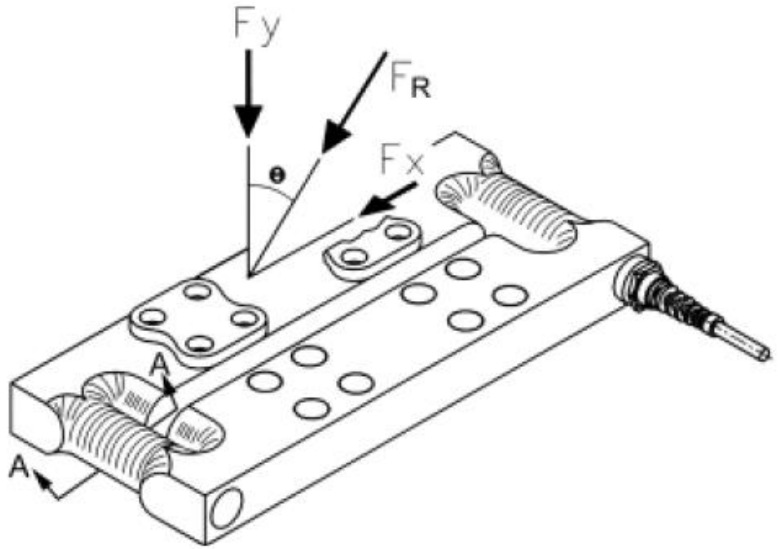
- Capacities: 10, 20 kN
- Measuring range: 1-100% of nominal
- Made for profile measuring
- Transducer in stainless steel, KIP-1 M also possible in stainless steel
- Small with high accuracy, but limited force direction and bending moment
- KIP-1 M can be customized





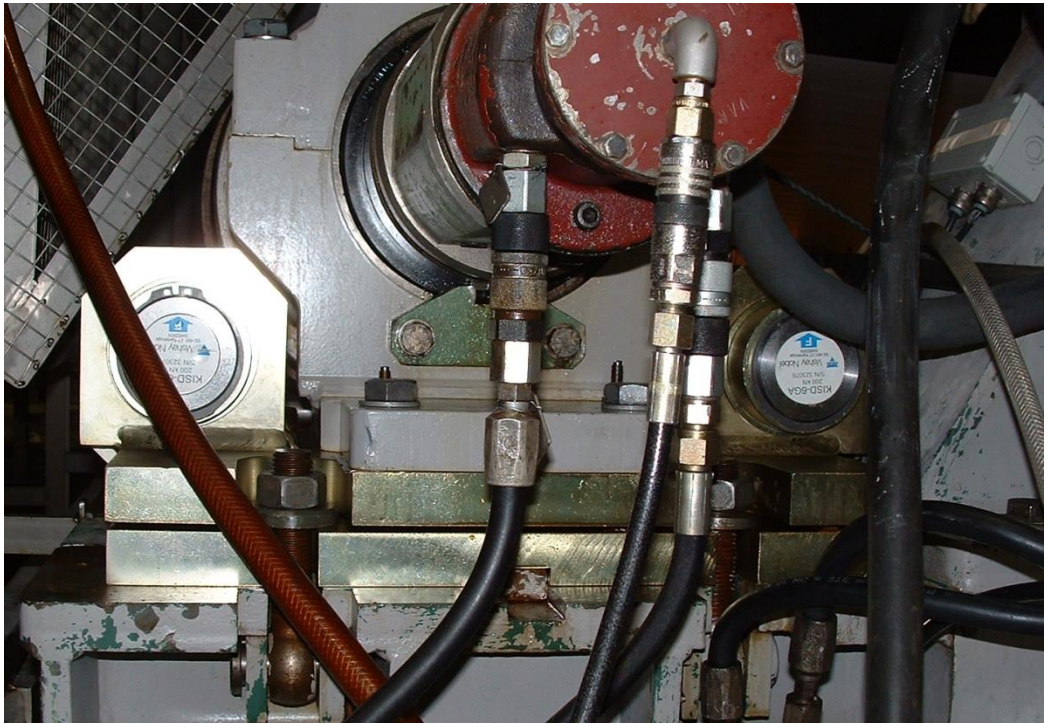
HTU

- Capacity 9, 28, 45 and 90 kN.
- Measuring range 1-100% of nominal load.
- Low built, stainless steel, high accuracy and temp. compensated.
- X and Y measurement.



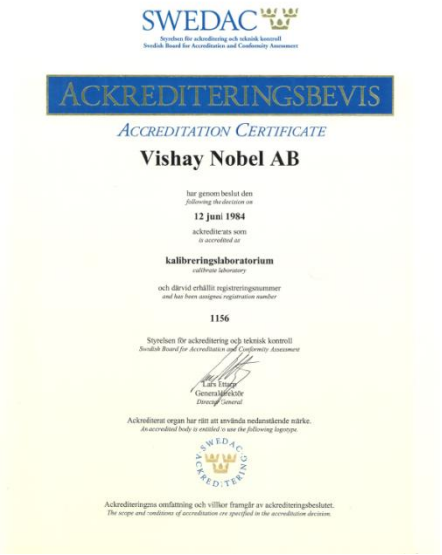
Special

- Some applications requires special force measurement units



Accredited Laboratory AMP 1156

- Accredited Laboratory – Force enl. SS-EN ISO 17025:2005, sedan 1984.
- Performs certified calibration of force measure equipment with full traceability to national standard
- Calibration can be performed according to Nobel validated methods or according to standard SS-EN ISO 376.
- Accredited in the range 2 N to 2 MN. Extended measurement accuracy 2 N to 2 kN, 0,02% (dead weight), 2 kN to 1 MN 0,05% and 1 to 2 MN 0,1%.


SWEDAC

ACKREDITERINGSBEVIS

ACCREDITATION CERTIFICATE

Vishay Nobel AB

har genom beslut den
following the decision on

12 juni 1984

ackrediterats som
is accredited as

kalibreringslaboratorium
calibration laboratory

och därvid erhållit registreringsnummer
and has been assigned registration number

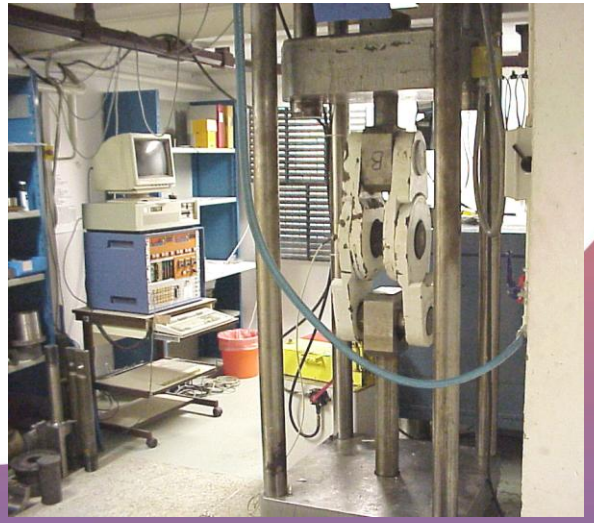
1156

Styrelsen för ackreditering och teknisk kontroll
Swedish Board for Accreditation and Conformity Assessment

Lars Unger
Generaldirektör
Director General

Ackrediterat organ har rätt att använda nedanstående märke.
An accredited body is entitled to use the following logotype.

Ackrediteringens omfattning och villkor framgår av ackrediteringsbeslutet.
The scope and conditions of accreditation are specified in the accreditation decision.



Visit to Degerfors Production