LEEA 085 - Guidance to The Use and Care of Load Measuring Devices

Lifting Equipment Engineers Association

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LEEA Guidance to The Use and Care of Load Measuring Devices

Document reference LEEA 085 Version 1 dated 31/07/2022

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Published by the

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Contents

1.0 Foreword

During LEEA audits it has been noted that there are several issues about the requirements for the use and care of load cells and other load measuring devices. This was highlighted during a very popular engineering programme on television.

Scenario: A lifting operation was being carried out and during the sequence, there was a shot of the team supervising the lift when it was noticed that a load cell was in the line monitoring the loading. The company carrying out the operation is a LEEA member, and coincidentally they were due to be audited soon after the broadcast. During the audit, the show in question was brought up and they were asked if they had a Report of Thorough Examination for the load cell in question.

The response was: *'No. But we have a calibration certificate for it. That's the same, isn't it?'*

This general misunderstanding was the driver behind this Guidance Document.

It has been the experience of LEEA auditors over the years, that not all users understand the classification of load cells and the legal duties when using them. This guidance aims to help.

2.0 Introduction

This aim of the guidance is not to describe the operation or the calibration processes of load measuring equipment but is to advise both the Duty Holder and the user in their requirements and responsibilities. It does not apply to load measuring equipment permanently installed in cranes.

It is to advise about the relevant national legislation and standard requirements that duty holders of this type of equipment are to follow. To help to clear up some confusion about the use, thorough examination, and maintenance requirements of load measuring equipment, we must start at the beginning.

The UK's Lifting Operations and Lifting Equipment Regulations 1998 (LOLER), Regulation 8 defines the following:

A lifting operation is defined as: *"An operation concerned with the lifting or lowering of a load"*

An accessory for lifting means: "*Lifting equipment for attaching loads to machinery for lifting."*

Additionally, DIRECTIVE 2006/42/EC, (Machinery Directive) and the Supply of Machinery (Safety) Regulations SOM(S)R for the UK states that:

'lifting accessory' means a component or equipment not attached to the lifting machinery, allowing the load to be held, which is placed between the machinery and the load or on the load itself, or which is intended to constitute an integral part of the load, and which is independently placed on the market; slings and their components are also regarded as lifting accessories."

It also includes any lifting accessories that attach the load to the equipment in addition to the equipment which carries out the actual lifting function. The scope of the relevant regulations is therefore very wide.

When load measuring devices are used for either loose load testing of equipment or monitoring the live lifting of loads, they are classed as a lifting accessory under relevant national use legislation.

Therefore, load measuring equipment carrying out these roles, are to be defined as lifting accessories and are to be used and cared for in accordance with the relevant national legislation. They are to be inspected or thoroughly examined and issued with a current report of inspection/thorough examination before use.

3.0 Types of Load Measuring Device

Within the recognised standards, a Load Measuring device is defined as

'*a force-proving instrument whole assembly from the force transducer* (load cell itself) *through to, and including, the indicator'*.

Force Proving Instrument – The complete assembly i.e. the load cell and indicator

Force Transducer – The Load Cell itself

Indicator – The Display of the load (could be separate indicator or integrated into the load cell itself.

In simple terms when tension or compression is applied, it creates a change to an electronic signal. It then converts this change and reproduces it as a digital readout on the indicator provided, whether permanently fixed to the test bed or portable measuring device (load cell). There are several types of load measuring device and below is a brief description of each:

3.1. Tensile load cell

A billet of high strength metal with two suitably sized holes for attaching the manufacturers supplied or their recommended shackles. The billet incorporates strain gauges which measure the strain in the billet in order to determine the applied load. Alternatively, it may look like an "S" shape which may also be known as an S Beam or Z Beam load cell. These can also be used as a compressive load cell. Tensile load cells are used to measure the pulling forces that are transmitted axially between the load and the hook or connection on a pulling machine or hoist. Tension might be described as the action-reaction pair of forces acting at each end of an item.

3.2. Compressive load cell

These are used to measure compression forces, utilizing strain gauges within the load cell which are bonded to the metal.

When the load cell is compressed, the strain gauges bonded to the load cell, detect the strain in the metal and correlate that strain to the applied load. It is this which is measured to determine the compressive force. They may be used between a jack and a load, or a load and the floor i.e. they may be found kept in situ below storage tanks.

3.3. Load pin & shackle

These tend to be used on shackles of various sizes that are usually in regular use, or where a billet load cell is impractical. They are used in many sectors and are popular in Offshore use and Entertainment Light/Sound gear rigs. A load pin will generally be in double shear and will measure the strain accordingly. Load pins can be used to replace existing pins/bolts which allows minimal change to the system that is to be measured. The load shackle is a prime example of this, where the load bearing pin is replaced by a new machined pin for strain gauges and fitted with a strain transmitter to an indicator.

3.4 Hydraulic system

Works by converting hydraulic oil gauge pressure to a load reading. They must be used with a calibrated gauge and a table showing the equivalent hydraulic pressure to load if it is not marked on the gauge itself. Commonly found on portable pull testers and some makes of test bed.

3.5 Spring scales/ Mechanical dynamometers /'Load clocks'

Heavy duty scale used for suspended weighing of large, heavy items. They should be calibrated. They are often used to weigh items to ensure they do not overload a crane or other lifting device where other forms of indicator are not present, as well as providing a weight indication for the load to inform the user. These will not be referred to again within this document.

4.0 Types of Use

The following information outlines the way the various load indicators are used:

4.1 Tensile or compressive test

Where a portable or permanent, load measuring device is fitted to horizontal test beds and vertical test rigs, whereby both ends of the test piece are restrained, and one end applies tension or compression through a hydraulic ram or other powered machine.

4.2 Loose load test

Where a portable or permanent, load measuring device is used with the suspended load testing of lifting equipment or supporting structures, i.e., in the line of a suspended test load using test weights or water bags. If pre-calibrated test weights are used this may not be necessary, provided the evidence of calibration can be verified.

4.3 Live lift monitoring

This is where a load measuring device is incorporated into the lift to monitor the weight of a load while is being moved from point A to B.

Also, this is also used where lighting rigs or scenery, for example, are continuously moved around the stage area during a performance. In these cases, there may be numerous load measuring points fitted to the rigging all connected to a control readout panel.

5.0 Standards and Legislation

Calibration of load measuring devices generally falls into under the following applicable standards:

5.1 Applicable Standards

BS EN ISO 376 – *Metallic materials Calibration of force-proving instruments used for the verification of uniaxial testing machines*

This covers the calibration requirements for the load measuring devices (*force-proving instruments)* that are used to calibrate testing rigs (*uniaxial testing machines).* This level of calibration is unlikely to be necessary in the general lifting industry but may be relevant for test houses. Due to the associated costs involved and the level of traceability, there are relatively few companies correctly offering this type of calibration. This is required no later than every 26 months.

BS EN ISO 7500-1 – *Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension / compression testing machines - Verification and calibration of the force-measuring system*

The procedure to be followed for calibrating/verifying testing machine(s) using a load measuring device that has been calibrated in accordance with ISO 376. This is required every 12 months.

These testing machines are then able to be used to verify load measuring devices which will then be issued with a Certificate in accordance with the testing company's own ISO 9001 Quality System.

If a hydraulic pressure gauge is used this may be verified in accordance with BS EN ISO 837-1:1998. *Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements, and testing.*

This is the standard for calibration of hydraulic gauges for portable hydraulic pullout testers/strain bridges. Again, this is required every 12 months.

However, if the gauge is a part of a test machine, then BS EN ISO 7500-1 will be followed.

Note: There is one other current standard for the calibration of load cells: BS 8422-2003 - Force measurement. Strain gauge load cell systems. Calibration method. - However, this is rarely seen or referred to and has not been updated for nearly two decades. Also, it may require up to a 14-page certificate to be issued!

LEEA recommends in this case, best practice is to follow the requirements of the two main ISO standards as required. In addition, to produce a certificate, the testing company's own ISO 9001 verified procedure for load measuring devices is to be followed.

This is to be carried out every 12 months.

5.2 Legislation requirements

5.2.1 Tensile or compressive test (See 4.1)

The equipment used is covered by the relevant national use of work equipment legislation (*for example Directive 2009/104/EC– EU Work Equipment Directive in Europe and the Provision and Use of Work Equipment Regulations 1998 in the UK*), for the country they are used in.

While they are used for the load testing of lifting equipment, these work by applying tension between a lifting machine/ accessory, and a fixed point. Alternatively, by compression only in a purpose made testing rig. As they do not carry out a lifting operation, (no actual load is lifted), they are not classed as lifting equipment.

Even so, there is still the potential for failure of the equipment under test, and they should only be used with suitable guards, relevant safety devices, documented risk assessments and method statements (RAMS). They are also to be maintained and inspected in accordance with the applicable national use of work equipment legislation. If a load measuring device is fitted within the machine, an annual calibration report is required stating it is a minimum of a Class 2 load measuring device.

5.2.2 Loose Load Testing (See 4.2)

A calibrated load measuring device is used with suspended test weights to load test lifting equipment or supporting structures. In these cases, load cells are classed as lifting accessories and therefore, they must be thoroughly examined and reported on in accordance with relevant national use of work equipment or the applicable lifting equipment legislation if this is in place(*For the UK this is LOLER1998 and must be no later than 6 months)*.

An annual calibration report is required stating it is a minimum of a Class 2 load measuring device. The load cell shall be verified by a test machine calibrated in accordance with (BS EN) ISO 7500-1, such that the sum of the inaccuracies of the load applied and the load cell readings do not exceed ±2%. Where containers may be required to house the weights, the self-weight of these containers must also be included.

As this is an actual lifting operation with all the inherent risks, relevant national legislation with regards to lift plans etc., standards for the equipment and LEEA Membership requirements will apply where necessary.

5.2.3 Live lift monitoring (See 4.3)

This is where a load measuring device is incorporated into the lift to monitor or weigh the load while it is being moved from point A to point B.

The entertainment industry frequently carries out complex lifting operations with multiple hoists etc. running simultaneously. This involves statically indeterminate loads, and calculated load values are near impossible to achieve without use of multiple load cells. This can involve complicated systems using hundreds of load cells, multiple display devices and alarms.

This is also used where lighting rigs or scenery for example are continuously moved around the stage during a performance As this is an actual lifting operation with all the inherent risks, relevant national legislation with regards to lift plans etc., standards for the equipment and LEEA Membership requirements will apply where necessary.

6.0 Calibration Standards - Reports and Certificates

A calibration certificate shows the accuracy of the load measuring device under test conditions and is to be issued to the load measuring device duty holder.

6.1 Verification Report (or Calibration Certificate) requirements ISO 7500-1

The following information and evidence are to be kept on file for calibration testing machines:

a) reference to the relevant part of ISO 7500, i.e., ISO 7500-1.

b) identification of the testing machine

1. manufacturer,
2. type,
3. year of manufacture if known,
4. serial number
5. specific identification of the force indicator (mark, type, serial number) - if applicable,

c) location of the machine.

d) type, class and reference number of the force-proving instrument used, calibration certificate number and expiration date of the certificate.

e) calibration temperature.

f) date of verification.

g) name or mark of the verifying authority.

Results of verification

The results of verification shall mention:

a) any anomaly found during the general inspection.

b) for each force-measuring system used,

i. the mode of calibration (tension, compression, tension/compression),

ii. the class of each range calibrated

and, if requested,

iii. the discrete values of relative errors of accuracy, repeatability, reversibility zero and resolution.

iv. the lower limit of each range to which the assessment applies.

The reference to this report is to be included on the test company's verification report (see 6.3)

6.2 Verification Report (or Calibration Certificate) requirements – ISO 376

If a force-proving instrument (Highly Accurate or Reference Load Cell) has satisfied the requirements of this International Standard at the time of calibration, the calibration authority shall draw up a certificate, in accordance with ISOIIEC 17025, stating at least the following information:

a) The identity of all elements of the force-proving instrument and loading fittings and of the calibration machine.

b) the mode of force application (tension/compression).

c) that the instrument is in accordance with the requirements of preliminary tests.

d) the class and the range (or forces) of validity and the loading direction (incremental-only or incremental / decremental);

e) the date and results of the calibration and, when required, the interpolation equation.

f) the temperature at which the calibration was performed.

g) the uncertainty of the calibration results

h) details of the creep measurement, if performed

The maximum period of validity of the certificate shall not exceed 26 months. A force-proving instrument shall be recalibrated when it sustains an overload higher than the test overload =r:B.1) or after repair.

6.3 Certificate of Calibration (Minimum Information Required)

The requirements of the test company's load cell testing regime in accordance with the company's ISO 9001 accreditation. (See Annex A):

a) The following statement (or similar wording) is to be made on the calibration company's test certificate

'This confirms that the Testing Machine used has been verified in accordance with ISO 7500-1:2018 - Part 1: Tension/Compression Testing Machines Verification and calibration of the force measuring system'

b) Identification of the customers device
   i) Manufacturer,
   ii) Type,
   iii) Year of manufacture if known,
   iv) Serial number
   v) Load Cell WLL

c) Test Machine Used
   i) Type
   ii) Class
   iii) Reference number
   iv) Calibration certificate number (iaw ISO 7500-1)
   v) Expiration date of the certificate.

d) Location of the test machine; (Calibration Company premises or Customers Premises)

e) Type of test carried out –
   i) Tensile,
   ii) Compression

f) Temperature at the time of Calibration

g) Reference to the inspection/work report (*if applicable*)

h) Date of calibration.

i) Date next calibration is due (no later than 12 months)

j) Stated Accuracy of the Load Cell on test. (*To be stated as + or – percentage of either full scale or applied load*)

k) Results of tests carried out including % errors (Table)

l) Name or mark and address of the calibration company

m) Name of company approved/authorized tester

n) Signature of tester

o) Date of this report

7.0 Legislative requirements

Load cells are to be supported by the following legal documents:

7.1 Supply

When new, load measuring devices are required to be supplied with

- Manufacturers Certificate (Guidance - LEEA-030.2e1 - 3)

- Manufacturer's instructions for use. (Guidance LEEA 062)
- Manufacturers Calibration Certificate

Note: This may be attached to the Manufacturers Certificate or Declaration of Conformity.

- Other conformity declarations as required by legislation.

Note: For the UK and EU markets the relevant Declaration of Conformity is required by the legislation.

Please refer to LEEA 030.1e1-9 as applicable.

The certificates or declarations must list the legislation, regulations, or directives that it complies with. (For the EU and UK these will be EU Machinery Directive/ SOM(S)R/ and for accompanying wireless systems the Radio Equipment Directive or the Radio Equipment Regulations (UK)

Where products are supplied with a Declaration of Conformity, they are also to bear the relevant Conformity mark (e.g., CE/UKCA for the EU/UK) as applicable for the country or economic area where it is to be placed on the market.

7.2 Inspection and Thorough Examination

In accordance with national use legislation (PUWER in the UK) inspections must be carried out at regular intervals. These are also required at frequent intervals (pre-use or daily checks as applicable) to check for general wear and tear as well as correct operation of the readout on the indicator. Attention should also be made to the frequency, intensity and type of use. Where necessary a written scheme of examination may be used.

One issue that may occur is known as 'Zero Drift'. This is where the calibrated zero point has moved over time and with usage. A small amount may be tolerable but should be referred to in the manufacturer's instructions for use. If this is continuing regularly it may show internal issues or possible overloading and the manufacturer should be contacted for advice. If a known accidental overload has occurred, the manufacturer is to be contacted and may very well recommend returning the load cell to them for verification.

When a load cell is classed as a lifting accessory, i.e. if it is to be used as a piece of lifting equipment for load monitoring, then it is to be treated in accordance with the requirements of the national legislation for the country of use. They are to be supported by a current Report of Thorough Examination or inspection certificate stating that they are safe to use.

Note: For the UK this is required no later than 6 monthly – LOLER Reg 9 applies

The thorough examination is to have been carried out in accordance with the manufacturers guidelines and will include dimensional checks, signs of external damage i.e. nicks, cuts, cracks, gouges, wear, deformation etc.

To assist with these inspections and examinations, it is recommended that the manufacturer supplies a list of relevant points requiring periodic checking, along with dimensional drawings of the load cell in all planes and they must specify the acceptable wear (if any) on the relevant points on the product.

7.3 Use and maintenance

Manufacturers are obliged under legislation to supply Instructions for Use with their products. These are to be specific to the type and model supplied and users are to follow them. They are to show or explain how the product is intended to be used and how it is to be operated safely. In addition, they are also required to list types of *'reasonably foreseeable misuse'*. This means the use of their product in a way not intended in the instructions for use, but which may result, from previous examples or experience, in near miss or actual injury or damage caused by predictable human behaviour.

These instructions should also give information on the maintenance that may be performed by the duty holder/operator, such as general cleanliness or battery changing or charging. They should also give details of the times when they should be returned to the manufacturer for specialized maintenance or repair such as following unintentional damage or other situation resulting in a loss of calibration or accuracy.

Annex A - Example of Company Verification/Calibration Certificate

(information in italics is for guidance only)

Name or mark and address of the testing/calibration company **Calibration Certificate**

'This statement is to confirm that the testing machine used has been verified in accordance with

ISO 7500-1:2018 – Metallic Materials-Calibration and verification of Static Uniaxial Testing Machines

Part 1: Tension/Compression Testing Machines - Verification and Calibration of the Force Measuring System'

Customers device details

Manufacturer	Type	Year of manufacture	Serial number	Load Cell WLL
		(if known)		

Test Machine Used *This is the testing machine owned by the testing company.*

Type	Class	Company Reference No.	Calibration certificate number	Expiration date
			(ISO 7500-1 Certificate)	

Test Machine Location; Testing Company premises or Customers Premises

Type of Test

Tensile		Compression		Other	

Temperature at the time and location of Calibration	*˚C or ˚F*
Reference to the inspection/work report - (*if applicable)*	
Date of calibration.	*##/##/202#*
Date next calibration is due (no later than 12 months)	*##/##/202#*

Stated Accuracy of the Load Cell on test. *+/- ###%*

Results of tests carried out including % errors (Table) (*example only-please use your original style if preferred***)**

Applied Load	Run result	% Errors
kg/t		
kg/t		
kg/t		

Name of company approved/authorized tester	
Signature of tester	
Date of this report	