Proposal for new standard

Determination of interface friction between painted parts.

Orientation

This standard specifies the method and conditions to evaluate interface friction between painted parts.

There is no international or national equivalent to this standard.

Contents

1 Scope and field of application

The standard describes laboratory testing for evaluation of interface friction between painted parts.

It is mainly intended to be used in the verification phase of new surface treatments that are being used in bolted connections, ex. truck frames.

The test method is based on a bolted joint and requires one device to measure clamping force and one equipment capable of applying a well-controlled pulling force at a constant speed with simultaneous recording of movement. These requirements can be fulfilled in different ways but are typically met using a commercial load cell and a commercial tensile tester.

The principle for the test method can also be used for evaluation of uncoated samples, or combinations of samples with different surface properties.

2 Abbreviations and definitions

dc = Outer diameter of bolt/nut flange (mm)

dw = Outer contact diameter of bolt head/nut (mm)

F = Clamp force, before pulling (kN)

F end = Clamp force after pulling (kN)

Fp = Pulling force (kN)

Fp,stat = Pulling force at onset of slip(kN)

Fp,dyn = Minimum pulling force at dynamic sliding (kN)

µ stat = Interface friction at onset of slip

µ dyn = Minimum interface friction during sliding

Dy = Outer diameter of spacer sleeve (mm)

Di = Inner diameter of spacer sleeve (mm)

H = Height of spacer sleeve (mm)

$$\mu_{stat} = \frac{F_{p,stat}}{2 \cdot F}$$

$$\mu_{dyn} = \frac{F_{p,dyn}}{2 \cdot F}$$

3 Apparatus

The apparatus can be divided into two main parts:

- Load cell
- Tensile test device

The principle for the test set-up is shown in Figure 1.

3.1 The load cell

The load cell should be adapted for the clamping force range expected in that particular test, see Table 1.

The accuracy of the load cell shall be ±2 % or better.

<u>Practical advice</u>

High load cells have generally shown better acceptance for (smaller) misalignments and non-parallelism as compared to low height force washers.

Depending on load cell design it may be necessary to use a sleeve inside load cell to ensure centring of the bolt.

It may be necessary to use washers to distribute the load more evenly across the compression area of the load cell – especially important when using smaller bolt dimensions.

3.2 The tensile test device

The tensile tester shall be capable of measuring, and recording, force and displacement simultaneously at a measurement frequency of min 100Hz.

The accuracy of the force measurement in the tensile tester shall be ±2 % or better.

The accuracy of the displacement measurement sensor does not need to be high – as long as it is repeatable within a test series.

A constant pulling speed of 1,2mm/min shall be used.

<u>Practical advice</u>

Consider grip opening vs. plate thickness early in the test. Some tensile tester grips will not open and will this put a limit on panel thickness.

3.3 Test equipment set-up

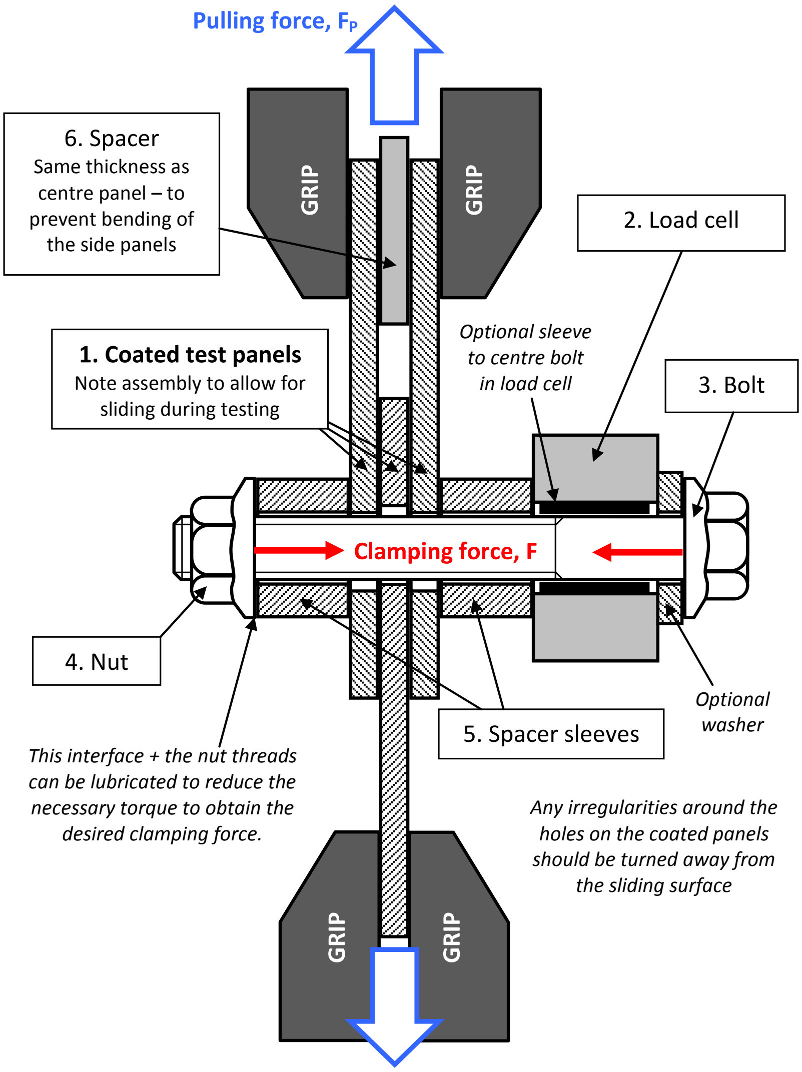

Figure 1 Test set-up in tensile tester, principle.

An example of a set-up is shown in Appendix 3.

4 Test panels

Unless otherwise stated the test panels should be in a state corresponding to serial production parts.

Normally a set of ten measurements is performed. Since each measurement requires three plates the total number of plates is thirty.

4.1 Preparation of test specimens prior to coating

Burrs and sharp edges should be removed from the test specimen prior to coating.

Surface roughness (prior to painting/coating): Ra < 2

Exceptions could be made if surface treatment prior to painting/coating normally includes shot blasting or some other mechanical or chemical treatment.

Cleaning and other pre-treatment should follow normal procedures for the applied paint/coating to be evaluated.

4.2 Painting/coating

Coating should be performed in the production line, or in a production like manner.

Test specimens should be coated on both sides.

DO NOT hang the samples in the main hole during coating as this will create marks/irregularities that could affect the interface friction.

Practical advice

When using pre-cut samples acc. to Appendix 1 the samples should be hung close to each other when coated in order to reduce the picture framing effect.

To assure sufficient samples with even coating layer thickness it is recommended to use dummy panels around the samples during coating.

4.3 Preparation after coating

Test samples should be handled so that the surface upon arrival at the test facility is representative for a painted/coated part coming out of the ordinary production line.

Test samples MUST NOT be cleaned with alcohol, isopropanol, acetone or similar solvents.

During shipping protect each panel separate in order not to get scratches on the surface.

DO NOT put any markings (paint, stickers, scribing/engraving) within 50mm from the main hole.

4.4 Preparation of test specimens from already painted parts

This is not permitted since it is very difficult not to affect the painted surface when preparing test panels from already painted parts.

5 Test procedure

5.1 General requirements

Avoid touching, or in other ways contaminating, the surfaces to be clamped.

Avoid condensation of water on the test samples

Unless otherwise agreed, the tests are carried out at room temperature (20-25°C).

5.2 Assembly of test panels

Push the panels together to allow for slipping during pulling and also align the panels to prevent rotation during subsequent pulling, see Figure 2.

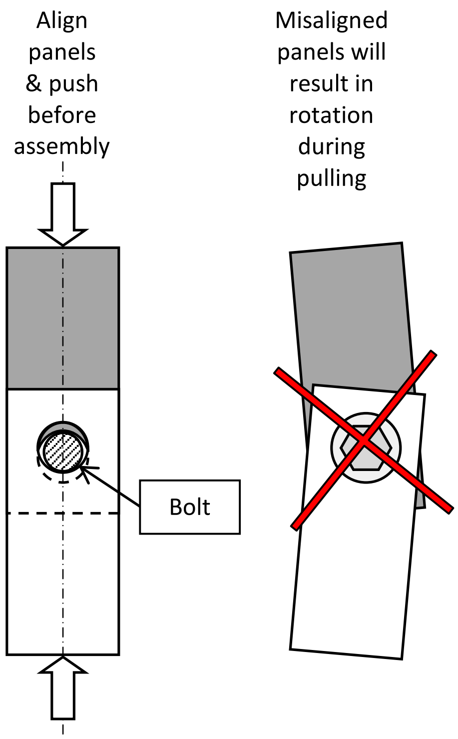

Figure 2 Assembly of test panels.

Tighten the bolt/nut to the specified clamping force interval, see Table 1.

(The clamping forces correspond to approx. 75% of proof load ± 10% acc. to ISO 898-1)

Table 1 Clamping forces (kN)

Thread	8.8 (kN)	10.9 (kN)
M8	16±2	23±3
M10	25±3	36±4
M12	37±4	52±5
M14	50±5	72±7
M16	67±7	98±10

Practical advice

By assembling the panels in a screw vice (with only moderate clamping of the parts) it is possible to align them, see Appendix 3.

5.3 Pulling

Fix the assembled test panels in the tensile tester, symmetrically along the pulling axis, remember the spacer, see Figure 1.

Depending on the stiffness of the machine and how the displacement is measured set the maximum displacement to 0,5-1,5mm (compare curves in Appendix 5) or observe the curve during pulling and stop pulling before or at the moment the holes have moved across the gap.

1. Note the clamping force (F) before pulling.
2. Pull. (1,2mm/min)
3. Record and save the force vs. displacement curve.
4. Note the clamping force after pulling (F end) as a reference.
5. After removing the assembled panels from the tensile tester look for signs of slipping between grips and coated panels.
6. Mark panels so it is clear what surfaces has been in contact - do not make any markings directly on the surfaces that has been in direct contact during slipping.

6 Evaluation and report

The general requirement is that the information given in the report, regarding the test objects and test parameters, should be sufficient in order for another test facility to repeat the test under similar conditions.

Deviations from normal behaviour shall be documented in the report, for example: slip between test samples and grip in tensile tester, signs of uneven contact at the clamped surfaces, sharp edges causing scratches, etc.

In some cases there is a clear onset of slip and the static and dynamic friction are readily evaluated, see Figure 3.

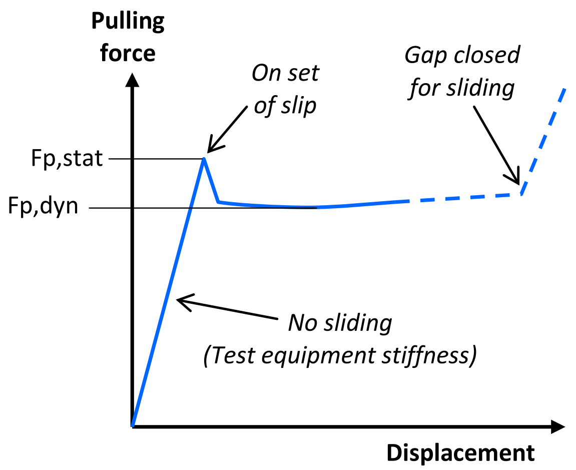

Figure 3 Evaluation of static and dynamic friction with clear onset of slip

In other cases the onset of slip is more gradual and an assessment of the slip point has to be made, see Figure 4

<u>The process for assessment of static and dynamic friction at gradual onset of slip is not yet established.</u>

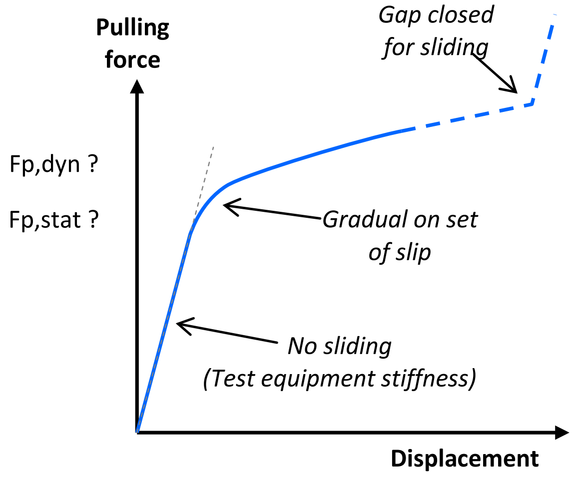

Figure 4 Evaluation of static and dynamic friction with gradual onset of slip.

Always use the clamping force before pulling in calculations of the interface friction, both for static and dynamic slip.

A layout for the test protocol is shown in Appendix 5

The recorded force vs. displacement curves shall be attached to the report.
An example is shown in Appendix 5.

7 List of appendices

Appendix 1	Test panel specification
Appendix 2	Spacer sleeve dimensions
Appendix 3	Test set-up, examples
Appendix 4	Parts information to report
Appendix 5	Test protocol & test curves

Appendix 1 Test panel specification

Geometry

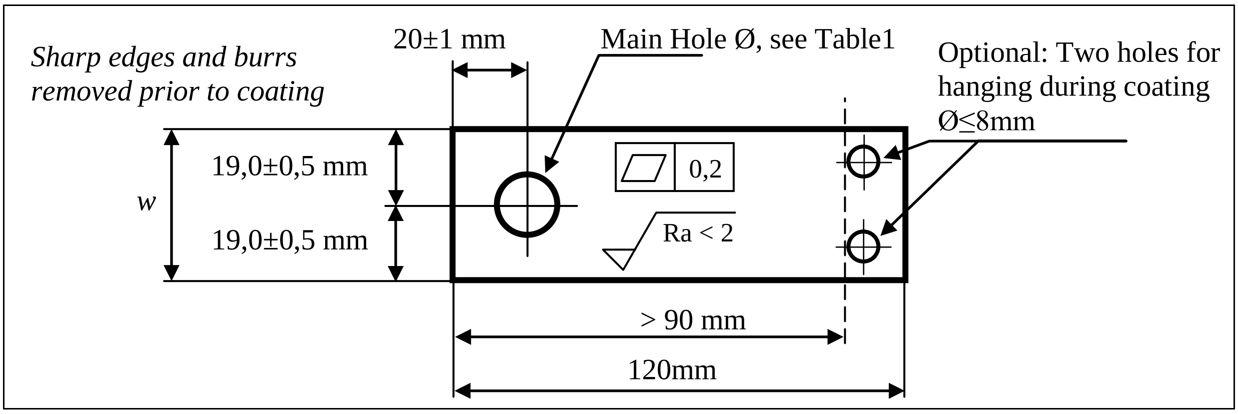

Figure 5 Test panel geometry

Flatness acc. to STD 112-0003, Surface roughness acc. to STD 120-0004

Table 2 Main hole diameters (tolerance H13) prior to coating

Thread	M8	M10	M12	M14	M16
Hole (mm)	9,5	11,5	13,5	15,5	17,5

Thickness

5-8 mm (Other thickness can be used if representative for actual joints)

To facilitate assembly the width, ***w*** (see Fig.1) should be the same for all samples.

Material

Steel with hardness ≥ 100HB

Appendix 2 Spacer sleeve dimensions

The spacer sleeve dimensions are based on flange nut geometry acc. to ISO 4161, see Table 3

Table 3 Spacer sleeve geometries (ISO 4161:1999)

	Flange nut (ISO 4161:1999)			Spacer sleeve		
Thread	**dc** [1)] (mm)	**dw** [2)] (mm)	**(dc+dw)/2** (mm)	**Dy** [3)] (mm)	**Di** [4)] (mm)	**H** [5)] (mm)
M8	17,9	15,8	16,8	17	8,1	8
M10	21,8	19,6	20,7	21	10,1	10
M12	26	23,8	24,9	25	12,1	12
M14	29,9	27,6	28,7	29	14,1	14
M16	34,5	31,9	33,2	33	16,1	16

1) Max value
2) Min value
3) ±0,1mm
4) -0/+0,1mm
5) ±0,5mm

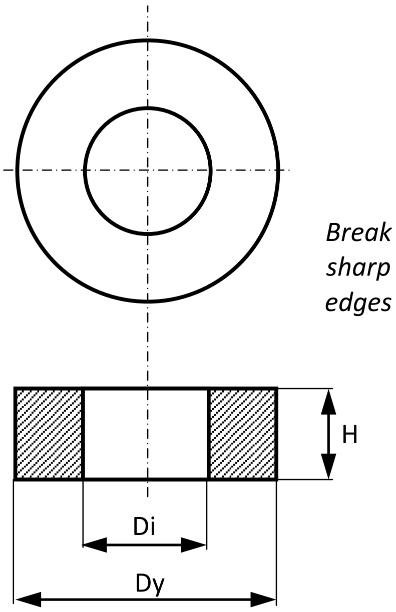

Figure 6 Spacer sleeve geometry

Appendix 3 Test set-up, examples

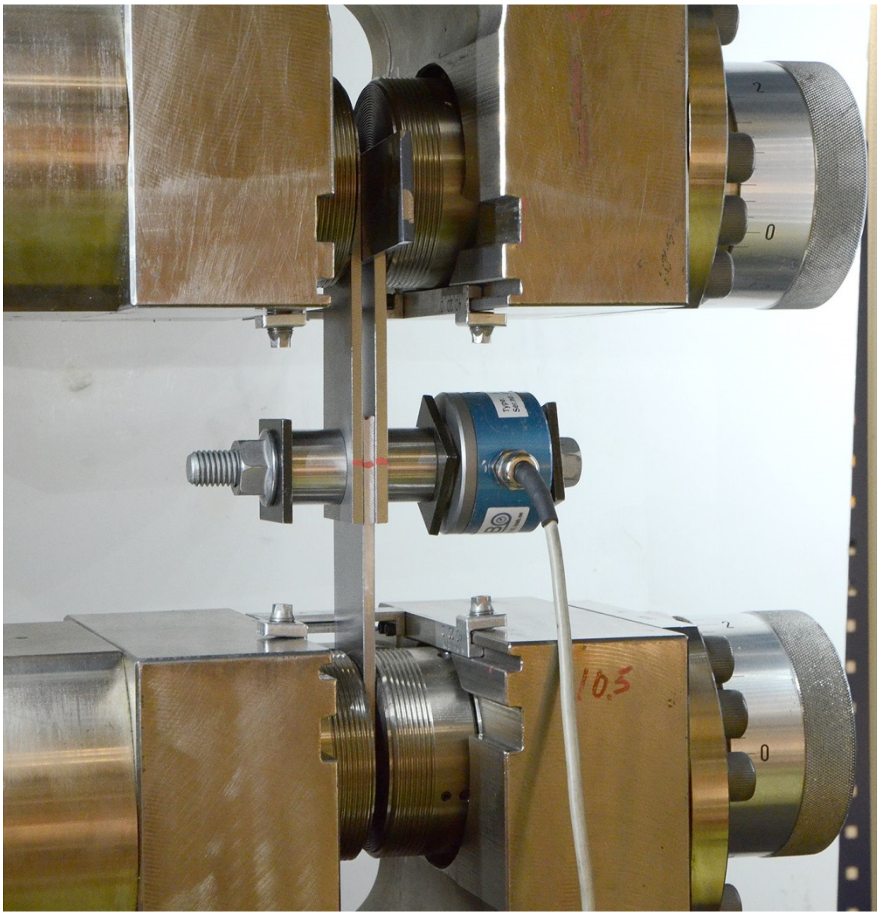

Figure 7 Example of test set-up in tensile tester with large hydraulic grips

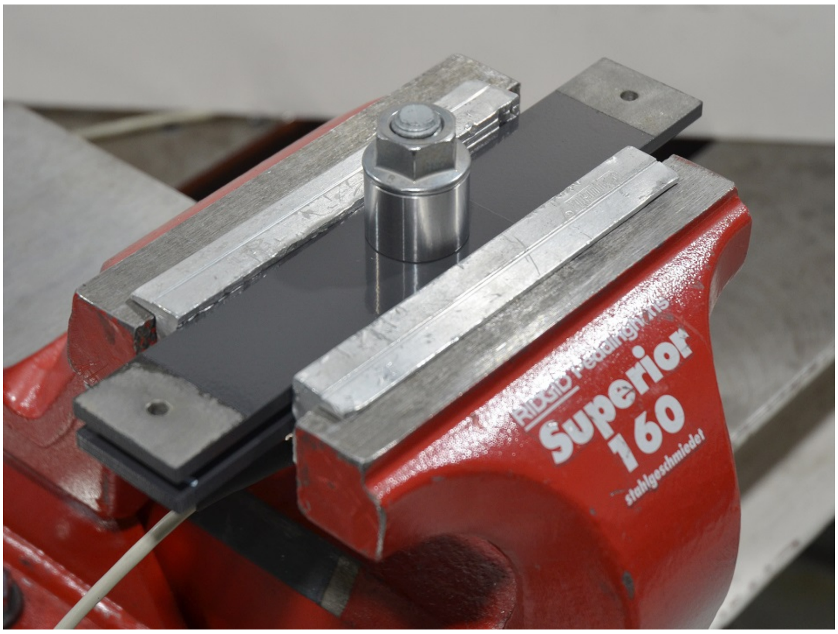

Figure 8 Assembly of test panels in a screw vice

Appendix 4 Parts information to report

Coated test panels

Mandatory information:

a) Type of coating

b) Date of coating

c) Batch number or other ID to identify the coating

d) Condition of surface (as received, other…)

e) Misc.

Test equipment

Mandatory information:

a) Type, capacity and ID for load cell

b) Type, capacity and ID for tensile tester

c) Pulling speed (1,2mm/min)

d) Misc.

Other

Mandatory information:

a) Dimensions of spacer sleeves

b) Temperature

c) Relative humidity

d) Misc.

Appendix 5 Test protocol & test curves

A suggested test protocol is shown in Table 4.

A set of ten force-displacement curves displayed in the same diagram is shown in Figure 9.

For these curves there is a clear on set of sliding and the dynamic friction is almost constant. For the third test (Third curve from the left) one can see that the sliding eventually reached the end of the gap and the bolt starts to act as a “stopping pin” for further movement.

Table 4 Suggested layout for the test protocol

Test no.	Clamping force prior to pulling, F (kN)	Clamping force after pulling, F end (kN)	Force at onset of sliding Fp,stat (kN)	Minimum force at sliding Fp,dyn (kN)	µ stat	µ dyn	Comments
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Average							
Max							
Min							

Additional information:

- xxx
- xxx

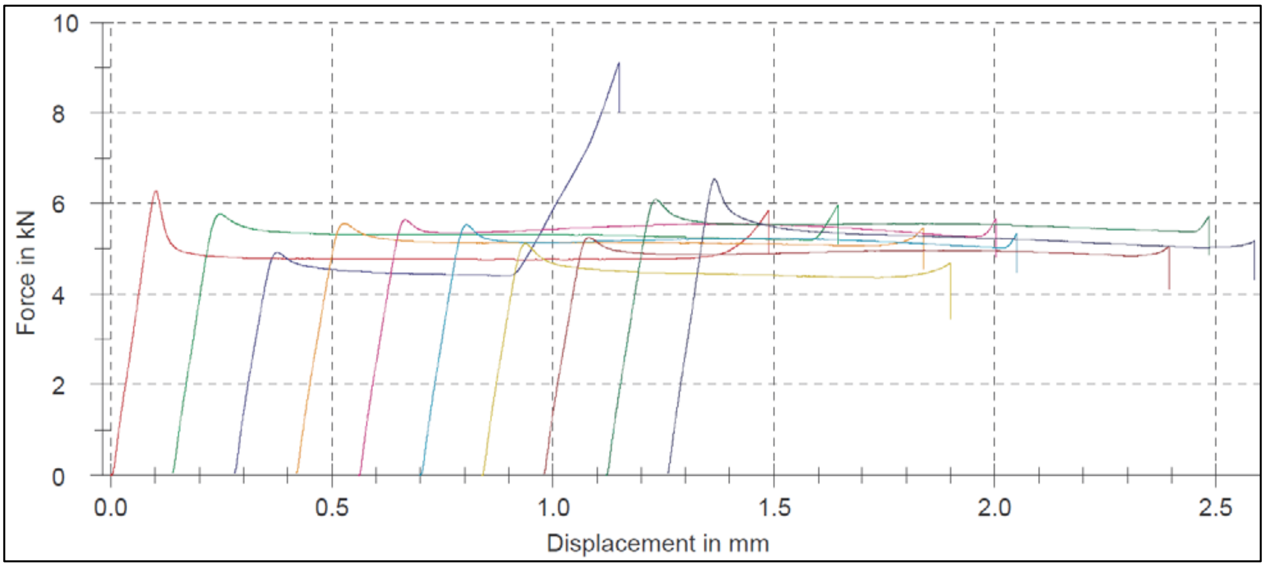

Figure 9 Examples of Force-Displacement curves