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Testing deviating bosses on L+G smart gas meters

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Management Summary

Several Dutch gas distribution grid operators have encountered the problem of L+G G350 gas meters, that are equipped with deviating bosses for the connection of the meter to the mounting bracket. This deviation was not discovered in the quality control processes which has led to considerable number of gas meters already installed in the field and a large amount in the warehouses.
Essential questions are raised to the (safety) risks this deviation is causing, which are:

1. Is there an acute safety risk for the meters already installed caused by the limited thread available on the bosses?
2. Is there a long term risk (caused by vibration or whatsoever) or are the connections expected to be gas tight over the lifetime of the meter ?
3. Is the adapter as proposed by L+G an effective solution for the problems?

From the tests performed it follows that there is no short term safety risk to be expected from the inadequate threading on the bosses of L+G gas meters already installed in the field (supposing adequate mounting and leak testing after mounting).

The mechanical connection between a boss (with inadequate threading) combined with some mounting brackets (i.e. with spring ring) is not up to standards. Although the tests results do not clearly show that there is a long term risk of leaking connections due to mechanical stress, the risk of failing connections is higher in comparison to connections with bosses fully threaded.

To assure adequate (and conforming to standards) threading on the bosses, the adapter proposed by L+G can be applied both to the meter base still in the warehouses as the already installed meter base. Attention shall be given to strict quality assurance procedures to guarantee leak tightness, both for mounting on the warehouse stock as refitting in the field.

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1 Introduction

Several Dutch gas distribution grid operators have encountered the problem of L+G G350 gas meters, that are equipped with deviating bosses for the connection of the meter to the mounting bracket. This deviation was not discovered in the quality control processes which has led to considerable number of gas meters already installed in the field and a large amount in the warehouses.
Essential questions are raised to the (safety) risks this deviation is causing, which are:

1. Is there an acute safety risk for the meters already installed caused by the limited thread available on the bosses?
2. Is there a long term risk (caused by vibration or whatsoever) or are the connections expected to be gas tight over the lifetime of the meter?
3. Is the adapter as proposed by L+G an effective solution for the problems?

Kiwa Technology has performed a test program to support answering these questions (chapter 2) . For that purpose a number of test samples was made available, with differing grades of non-conformity of the threading,
The results of the tests are given in section 2.2 and an analysis of the results and conclusions are presented in chapter 3.

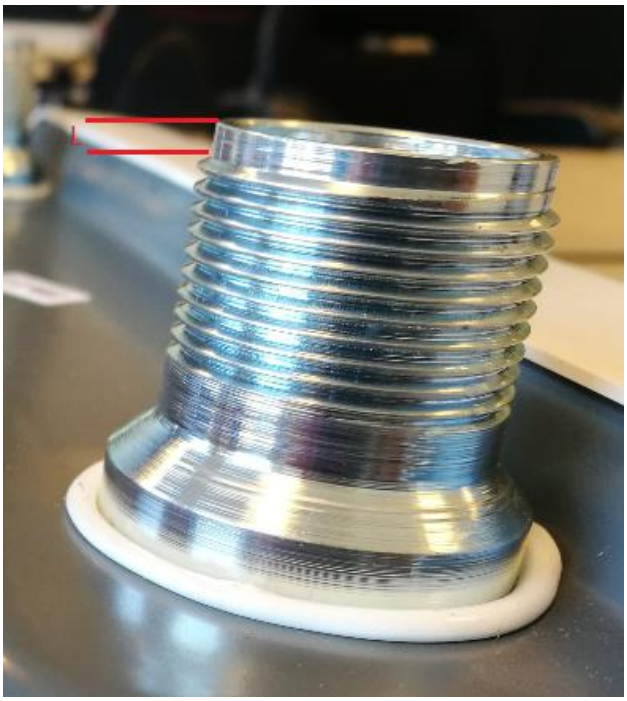
2 The test plan

2.1 The gas meter samples and brackets

In total 20 gas meters were supplied, of which 10 had inadequate threading on at least one of the bosses. The length of missing threads on the bosses of these meters were measured, shown in Table I.

Gas meter number	Qualification L+G	Distance L Left*	Distance L right*	# of turns left	# of turns right
1: SN:5612763757	Very bad	2,54	2,51	1 ¾	1 ¾
2: SN:5612762590	Very bad	2,55	2,56	1 ¾ +	1 ¾ +
3: SN:5612763810	Very bad	2,44	2,64	2	2
4: SN:5612763853	Very bad	2,59	2,57	2-	2-
5: SN:5612763841	Moderate	2,68	2,45	2-	2-
6: SN:5612762587	Moderate	1,30	2,49	2 ½ +	2-
7: SN:5612763837	Moderate	2,52	2,59	1 ¾ +	2
8: SN:5612763839	Moderate	2,62	1,39	2-	2 ½ +
9: SN:5612761293	NA**	2,55	2,47	2	2+
10:SN:5912701787	NA	2,38	2,38	2	2
11:SN:5612763851	OK	1,4	1,4	2 ½ +	2 ½ +

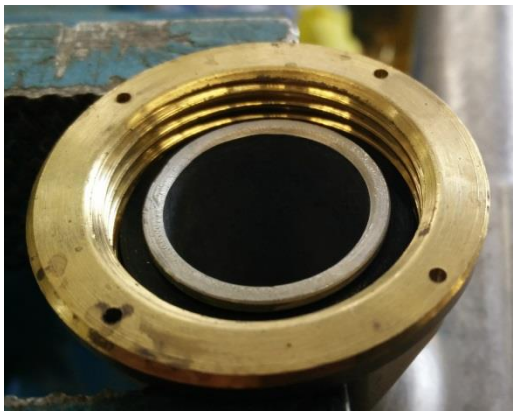
*) Left and right boss, as seen from front face of meter.
**) Not Available



Distance L is measured between the top flange and the point where the thread has its full depth (see picture).There is approx. ¼ turn to thread end.

The # of turns have been measured with one standard nut, so the number only refers to the specific boss combined with the used nut

The mounting brackets as these are in use by the grid operators are conforming to Gastec QA requirements KE 165. Comparing different brackets it follows that the thread length available on the nuts differs between bracket designs (but are conforming to KE 165). Especially brackets where spring rings block the nut (left picture) have less thread available. We classify these as sub-optimal in combination with the L+G gas meters with less threading.



2.2 The tests

2.2.1 Bending test

A weight of 40 kgs is put on the meter while it is mounted on a bracket (cranked hand-tight plus 90°[1]). Test according to KE 165, par. 1.10 “Weerstand tegen buigbelasting”.

Gas meter serial	Before test	After test
1: SN:5612763757	tight*	tight
2: SN:5612762590	tight	tight
4: SN:5612763853	tight	tight
11:SN:5612763851	not tested	not tested

*’tight’ means leak flow less than 10 cm^3/h.

All tests performed with mounting bracket with spring ring. Leak tests at 300 mbar overpressure.

[1] If not specified otherwise, this way of cranking is applied in all tests.


Left: bending test; right leak tightness test.

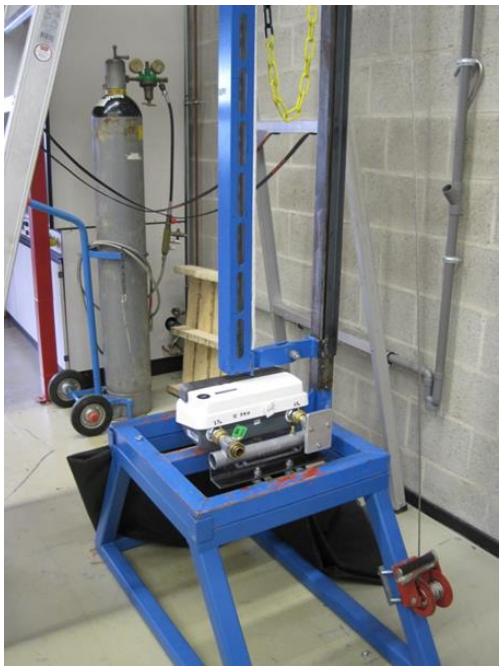
2.2.2 *Drop weight impact test*

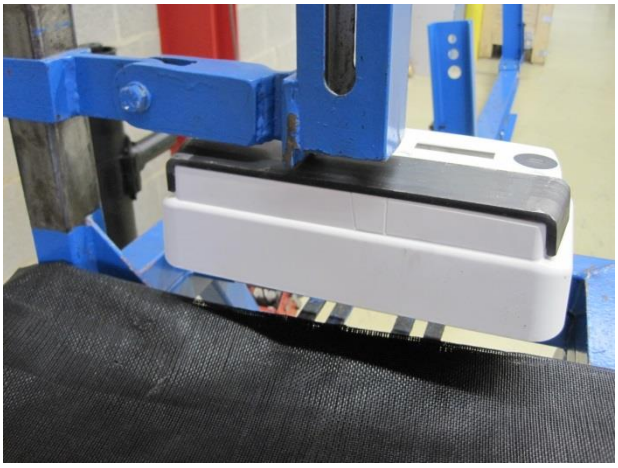
A weight of 2.5 kgs falling from 2 m height hits the gas meter on the front face. Test according to KE 165, par. 2.11 “Weerstand tegen stootbelasting”. The same meter/bracket combinations were used as for the bending tests (all with brackets with spring rings). New gaskets were used for every test.

Gas meter serial	Before test	After test
1: SN:5612763757	tight	leak on A+B (1.300 cm^3/h)
11:SN:5612763851	tight	tight
2: SN:5612762590	tight	tight
4: SN:5612763853	tight	tight

The tests with gas meters 1, 2 and 4 were repeated 3 times.

Drop Test results		**Test number**		
		1	2	3
Type meter bracket	1	Leak	No leak	No leak
	2	No leak	No leak	No leak
	4	No leak	No leak	No leak
	11	No leak	x	x





2.2.3 *Vibration test*

The vibration test was taken from KE 186, par. 1.4.4 “Resistance to dynamic loads”. This test in fact does not apply for the meter/bracket connection, but was chosen as to provide prove of the rigidity of the mounting of the gas meter and the bracket over time. Instead of a test period of 28 hours, 20 hours was chosen to be able to finalize one test per working day.
All vibration tests are summarized in the Table below.

Test #	Gas meter serial	Qualification meter bosses	Bracket with spring ring?	Leaking connections?	Leaking bosses?
1A	5612763850	OK	No	No	No
1B	5612762850	OK	No	No	Yes
2	5612763757	NOK	Yes	Yes	Yes
3	5612762590	NOK	Yes	No	No
4	5612763851	OK	No	No	No
5	5612756165	NOK	Yes	No	No
6	5612763837	with adapters	Yes	No	No

The first test has been started with an OK meter plus OK bracket. This test should confirm that a right combination of gas meter and bracket can withstand the test. Unfortunately the test has been halted (because of a broken bolt and damage to the bracket) after ≈ 3 hours (of the total test time of 20 hours). Due to the extreme stiff mounting the bracket failed. The connections between meter and bracket have been leak tested and proved to be tight. For further testing a new mounting rig is used, resulting in a more flexible mount.

The first test (test 1A) (that was halted because of a broken fixing) has been restarted. The result after 20 hours was that the connections were both leak tight, but the fixing of the bosses in the meter housing were leaking.

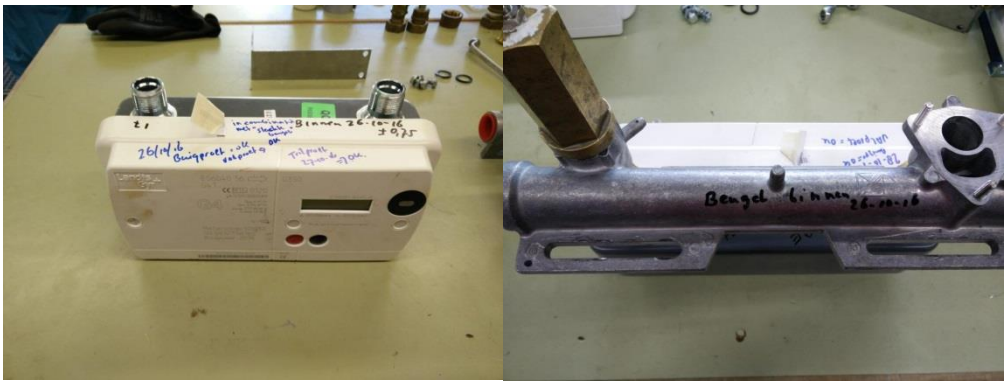
The second test with NOK meter and bracket with spring rings was halted after approx. one hour Although the nuts were fitted hand-tight plus 90º, one of the nuts had become loose. The meter was re-mounted with new gaskets and cranking to almost 180º instead of the standard 90º. The results after 20 hours were leak tight connections, but again one leaking fixing of the boss on the housing.

Third test NOK meter + bracket with spring ring, 90º cranking: tight connections and tight fixing of studs to meter housing.

Fourth test OK meter + OK bracket, 90º cranking: tight connections and tight fixing of bosses to meter housing.

2.3 Additional test

During an intermediate presentation and discussion of test results it was decided to expose an extra combination of gas meter and mounting bracket to all three mechanical tests (once per test). This combination was taken from some testing by a grid operator(meter SN: 5612756165, picture below) and by L+G classified as “QC passed”. The bracket (picture below) was fitted like standard with 90º cranking after hand-tight.



Initial leak tightness test was positive: no leak on both connections. After the bending test (conf. 2.2.1) the combination was leak tight. After the drop test (conf. 2.2.2) the combination was leak tight again. Finally, after the vibration test (conf. 2.2.3) the combination was still leak tight, even on the connections between bosses and meter housing.

2.4 Applying the proposed adapter

Two proto-type adapters (Annex 1, except flanged for C-spanner) and two meter samples with proto-type adapters installed were provided for testing by Kiwa Technology. Key aspects of the meters and bosses are listen in the Table below.

Gas meter number	Qualification L+G	Distance L Left*	Distance L right*	# of turns left	# of turns right
14: SN:5655023068	NA	Nil	Nil	3 ¼ +	3 ¼ +
15: SN:5655019097	NA	Nil	Nil	3 ¼ +	3 ¼ +

The adapters look well-machined and fit for purpose. The male threads are according to NPR 7028. The female threads have approx. 4.5 full turns to mount the adapter hand-tight on the meter boss (+ 1/4 turn cranking).
One combination of a meter with (proto-type) adapters and mounting bracket (with spring ring) was exposed to the bending test, the drop test and the vibration test. It proved to be leak tight after these tests.
Following these tests the momentum to unscrew the adapters was measured: 42.7 Nm.

The applied gasket dimensions differ from the dimensions in NPR 7028. The outer diameter is 29 (i.s.o. 28) mm and the thickness 3.5 (i.s.o. 2) mm. It is not to be expected that this will change the tightness of the connection, when fitted correctly.
Attention shall be given that the rubber quality meet requirements of EN 549, including resistance against exposure to natural gas.
The second design can only be mounted using a C-spanner, intended to prevent unwanted attempt to dismount. (Attempt to dismount will most probably lead to failure of the fixing of the boss to the meter housing.)
In the application of bonding substance (Loctite, Permabond) to secure the fixing of the adapter, care shall be taken to prevent contact of the bonding substance with the gasket.
It is to be assured that (vapours from) the bonding substance is(are) not affecting the properties of the gasket.

3 Analysis of results and conclusions

3.1 Analysis of results

Different combinations of NOK L+G gas meters and mounting brackets have been exposed to the bending, drop and vibration tests. These tests impose severe mechanical stress to the connections of the bosses to bracket. While only a limited number of combinations of gas meters and mounting brackets have been tested, it is not certain that the worst combination has been tested. Both the NOK meter base and the diversity of applied mounting brackets should be analysed to find the worst combination.

The bending tests shows that all tested combinations of meters and brackets withstand the mechanical force and the connections remain tight, even for the worst combinations of bosses and brackets.

Only in one drop test (in fact the first one), both connections were leaking after the test. All other tests (both with NOK and OK meters) showed no leaks after the drop test. It is suspected that in the first test the mounting was not flawless.

The vibration test was imposed to two samples of OK meters and OK brackets to provide evidence that a sound mounting of gas meter and bracket will withstand the test. The outcome is positive, except for the finding that the mounting of the bosses to the meter housing might be leaking after the test. Applying the vibration test to NOK meters and brackets with spring ring resulted in one case where the nut came lose in about one hour. Retightening the nut by cranking to almost 180º instead of normal 90º resulted in leak tight connection after the test.

With some restrictions (quality control of mounting the proposed adapters), the adapter poses a sound solution to overcome the inadequate threading of the bosses of the meters. The momentum measured to unscrew the adapters on the sample meter was unexpectedly low. For a permanent bond the value should be (much) higher.

3.2 Conclusions

Several combinations of L+G gas meters with inadequate threading of the bosses have been combined with different makes of mounting brackets and exposed to severe mechanical stresses (bending, shock and vibration). Mounting brackets that apply a spring ring to lock the nut to the bracket show less available threading on the nut for mounting, but are conforming to the Gastec QA standard KE 165. Combining the inadequate threaded bosses with these brackets results in a mechanically questionable connection.

The test results provide evidence that the already installed base of NOK meters do not impose an immediate safety risk, insofar the meters are mounted adequate and showed no leak after mounting.

The mechanical connection between a boss (with inadequate threading) combined with some mounting brackets (i.e. with spring ring) is not up to standards. In one vibration test (test # 2 in par. 2.2.3) a nut came loose after one hour, although it was cranked the standard way (hand tight plus 90º). This tests result shows that there is a long term risk of leaking connections due to mechanical stress, the risk of failing connections is higher in comparison to connections with bosses fully threaded.

To avoid any risk of leaking (by loosening of the nut by vibration or other external forces) occurring over the lifetime of the meters (over 20 years), it is advised to refit the installed meters with the proposed bosses. It is advised to provide for a well designed quality assurance system (fitting instructions, statistical quality checks or 100% leak testing after mounting) for the field mounting of the adapters, to assure leak tightness.

The momentum measured to unscrew the adapters on the sample meter was unexpectedly low. Further attention is needed to selection of the bonding substance.

Refitting the adapters also to the meters still present in the warehouses provides assurance that these meters have adequate threading to provide for sound fitting to mounting brackets (initial and over the lifetime of the meter). Again a thorough quality assurance system for refitting shall be applied.

Annex I: The adapter proposed by L+G

L+G has designed an adapter to apply to the inadequate bosses to provide for adequate thread length, complying to NPR 7028. The 2nd version drawing is shown below.