International Gas Union Research Conference

IGRC-Copenhagen 2014

September 17-19

Tools for adjustment of gas appliances to new gas quality

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Poster paper WP1-13_Rasmussen

Abstract

For many years Denmark was supplied with gas from the Danish part of the North Sea. This gas has a very stable quality and a relatively high Wobbe Index. Many appliances were optimised to this gas quality. E.g. condensing gas boilers were not used with their factory setting based on methane (G20), but were adjusted on-site to the high-Wobbe gas. This procedure avoided some of the problems that were observed with the first generation of condensing boilers. However, it also introduced new problems when the gas quality changed in 2010.

Since October 2010, part of the natural gas supply is imported from Germany. As a consequence, customers receive two distinctly different gas qualities, and Wobbe Index variations up to 8 % are now commonly observed. The transition to a more flexible gas supply was carefully prepared by a task force led by the Danish TSO and with participation of all DSOs and Danish Gas Technology Centre. Due to this work, the transition did not cause any major problems for the customers; only few problems with noise from gas appliances and performance problems at CHP plants occurred.

This paper will give details about tools that were developed to handle the gas quality variations:

- Adjustment of gas appliances in the field 'back to factory settings', including training of installers to perform this re-adjustment
- Adjustment of forced draught burners
- Solutions to noise problems
- Wobbe test burner – a simple method to measure the Wobbe Index of natural gases

Introduction

Until a few years ago Denmark had a very stable gas quality supplied from the Danish part of the North Sea. This gas has a very stable quality and a relatively high Wobbe Index. Many appliances were optimised to this gas quality. E.g. condensing gas boilers were not used with their factory setting based on methane (G20), but they were adjusted on-site to the high-Wobbe gas. This procedure avoided some of the

problems that were observed with the first generation of condensing boilers. However, it also introduced new problems when the gas quality changed in 2010.

Back to factory settings

Since October 2010, part of the natural gas supply is imported from Germany. Sometimes we import and sometimes we export natural gas to Germany. As a consequence, customers receive two distinctly different gas qualities, and Wobbe Index variations up to 8 % are now commonly observed. In the southern part of Denmark close to Germany, some noise problems were observed during this transition. Obviously, some gas appliances were not prepared for the "German" low-Wobbe gas now imported in some cases. Originally adjusted to the "fat" Danish gas these appliances developed problems when the "thin" German gas was delivered.

As a consequence, the Danish gas companies together with Sikkerhedsstyrelsen (Danish Safety Technology Authority) and Danish Gas Technology Centre decided to make a "Back to factory settings" campaign for appliances in the Danish gas system. More than a thousand installers were educated during this campaign.

Different methods are to be used with different gas supply in the grid.

With Danish gas in the pipes

In periods with supply of Danish gas the following diagram was used.

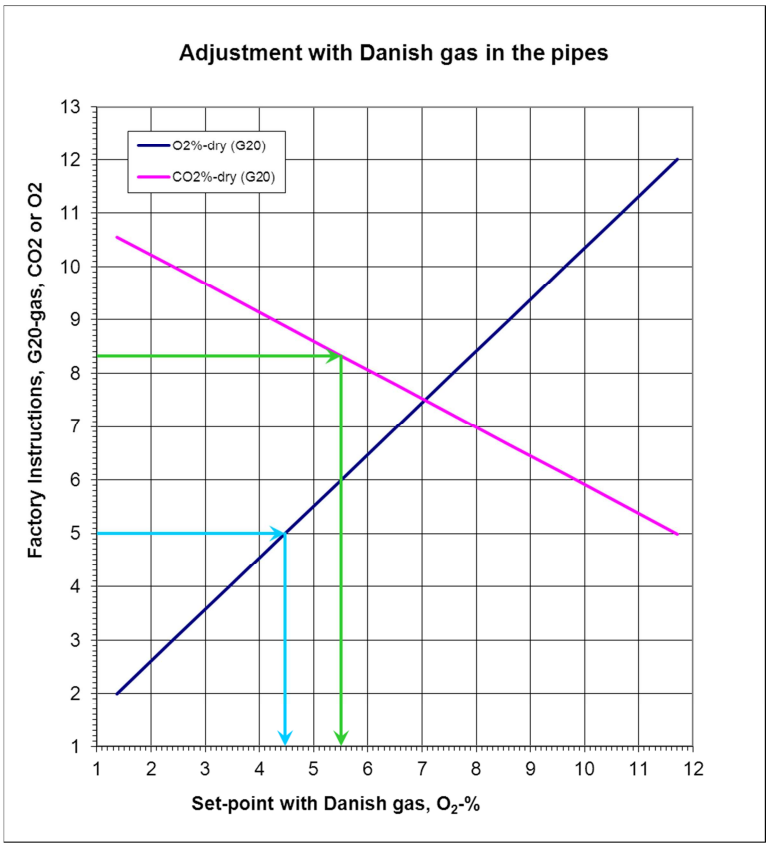

Figure 1. Factory setting with Danish gas in the pipes.

As an example, the factory setting is 5 % O_2 for a specific boiler with G20 (methane) as fuel. The boiler is then adjusted to 4.5 % O_2 with Danish gas in the pipes. That would give 5 % with G20. If the factory instructions advise to adjust to a CO_2 %, then again the diagram can be used. The installers were instructed to use this method at service intervals and also never to use CO_2 measurements for adjustment, only O_2 measurements.

With "German" gas in the pipes

However, now and then the installers were called out because of noise or other problems with the boilers when the German gas was in the pipes. The reason was always an earlier failure in the adjustment of the boiler. But with German gas in the pipes, how could they then adjust the boiler correctly to factory settings? The following method illustrated by the below diagram could be used.

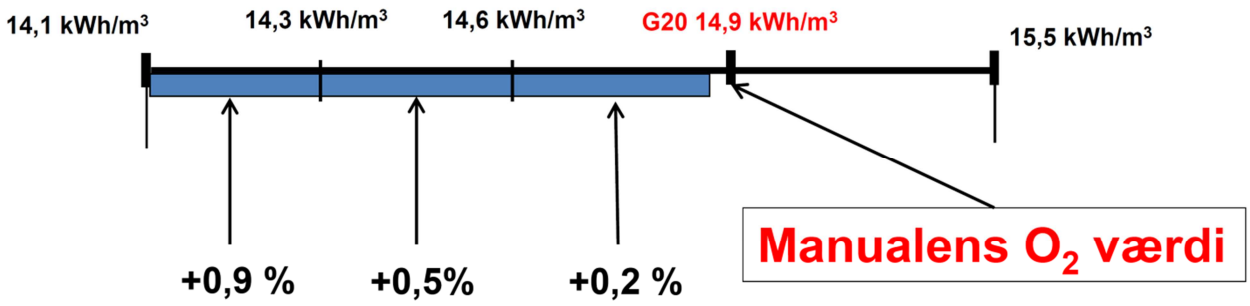

Figure 2. Instructions for installers with German gas in the pipes (In Danish).

If German gas with lower Wobbe Index is present, the boiler could be set back to factory settings by adding a small O_2 % to the factory instructions. If the installer is certain about the quality of the gas at e.g. in the range of 14.1 to 14.3 kWh/m^3, then by adding 0.9 % O_2 to the factory instructions, the factory setting is achieved. In this way the boilers could be set back close to factory settings even with German gas in pipes.

With unknown gas quality

If the quality of the gas in the pipes is unknown at the point of interest (at a consumer), it is possible to use another method. A very simple "Wobbe test burner" was constructed for that purpose (called the "bird cage" by some installers). See Figure 3. The steel grid around the burner is a safety precaution. The burner is very simple, but the development was not so simple. A Bunsen burner is set up with a closed exhaust, in which the O_2 % at the outlet is measured. The special construction makes it as independent as possible on gas pressure at inlet. The firing rate in the test burner is only about 600 W.

The pressure at the inlet is adjusted and when heated up the burner will give an O_2 % at the outlet only dependent on the Wobbe Index of the gas to the burner. The installers only need the usual equipment used for adjustment of boilers for determining the gas quality.

The Wobbe test burner has been adjusted and sealed for 3 % O_2 in the exhaust when supplied by G20 (pure methane). When Danish gas is in the pipes, the O_2 % will show 2.5 %, and with the "thinnest" German gas the O_2 % will show 4 %. If used for adjusting boilers, the difference from 3 % should just be added to the factory instructions for O_2 at that boiler, and the factory setting with the present gas in the pipes is achieved.

Figure 3. The simple Wobbe test burner, called the "bird cage".

Adjustment of forced draught burners

Previously, with the very constant Danish gas in the pipes, the forced draught burners could be adjusted very close to the limit for CO formation. However, with new gases in the pipes the burners must be adjusted far from this limit to avoid CO formation for all gas qualities. The reason is that the burners must be prepared for the great variation in Wobbe Index introduced by a random variation between Danish and German gas qualities. If the gas present in the pipes at the time of adjustment is unknown, the safety limit to CO formation must be included twice when adjusting the burner.

First, we find a so-called "tip-point", at which the CO emission exceeds acceptable limits. In Denmark the tip-point is found when the O_2 % is reduced to a point where the CO emission exceeds about 500 ppm. See Figure 4.

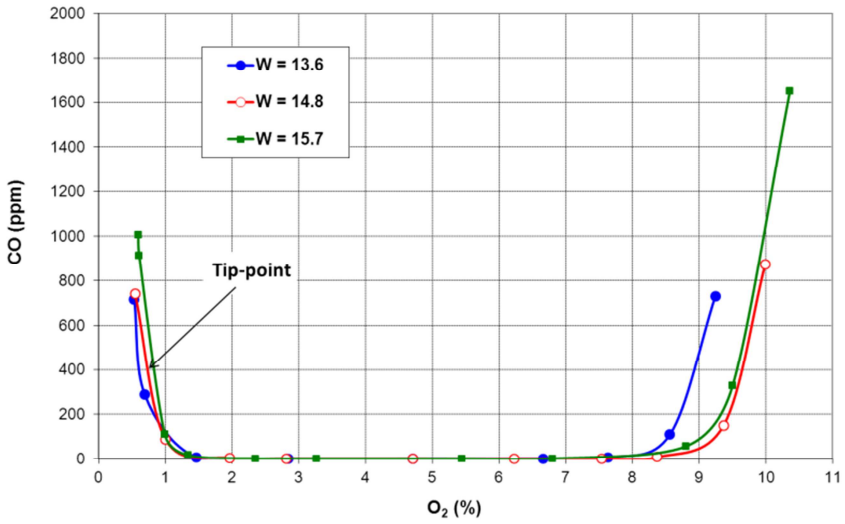

Figure 4. A typical O_2-CO curve for a forced draught burner.

Not only Wobbe Index, but also weather conditions influence the burner conditions.

The following method has been introduced in Denmark for adjusting forced draught burners. The diagram in Figure 5 is used.

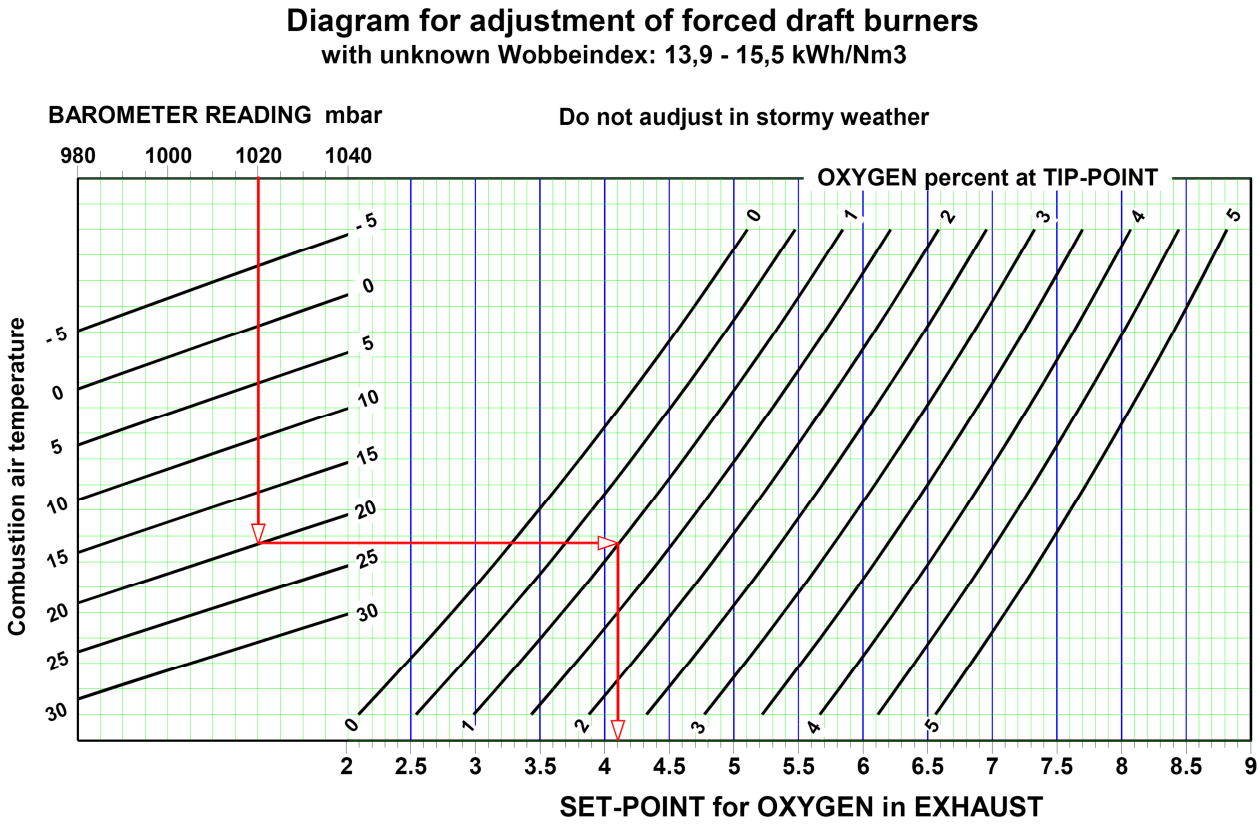

Figure 5. Diagram for adjusting forced draught burners.

In the example, the barometer reading was 1020 mbar (hPa). The combustion air temperature at the burner inlet is 20 °C. The tip-point was found at 1 % O_2 (giving too high CO). Now the burner should be adjusted to 4.1 % O_2 at the exhaust from the burner. With this adjustment the burner would be able to cope with any gas on the grid with Wobbe Index in the range of 13.9 to 15.5 kWh/Nm^3 (0 °C, 25 °C), any weather condition 980-1040 mbar and combustion air temperature in the range of 0°C to 30°C. Statistics were taken into account in the construction of the diagram.

Spreadsheet application

As an alternative to the diagram, an excel spreadsheet was made doing the same job. Figure 6 shows this alternative.

Set-point for oxygen percent in adjustment of large forced draft burners									**Ukendt Wobbetal 13,9 - 15,5 kWh/m^3_n**				**Aktuel dato 18-07-2014**
Middel forbrændingslufttemperatur i løbet af et år forudsættes at være ca. **15°C**													
Variationen af forbrændingslufttemperatur i løbet af et år forudsættes at være 0°C til 30°C i 99% af tiden													
												Gule felter:	indtast værdier
20	°C = den aktuelle forbrændingslufttemperatur før blæser											Kundeoplysninger mm.:	
	(Ved forvarmet forbrændingsluft anvendes rumlufttemperaturen)											**Combustion air temperature**	
1020	mbar = den aktuelle barometerstand på stedet											**Barometer reading**	
Lastpunkt min			CO	NO_x	**Lastpunkt max**			CO	NO_x				
O_2 (%)	CO (ppm)	NO_x (ppm)	($0\%O_2$) (ppm)	($0\%O_2$) (ppm)	O_2 (%)	CO (ppm)	NO_x (ppm)	($0\%O_2$) (ppm)	($0\%O_2$) (ppm)				
Kippunkt:													
1	500				0.9	400						**Tip-point giving high CO (measured)**	
Der indstilles til følgende iltprocent:													
4.11					4.02							**Set-point for adjustment of oxygen in exhaust**	
Måling af CO og NO_x i lastpunkter ved indstilling (målte værdier):													
4.1	59	61	73	76	4	90	100	111	124			**Emissions at set-pionts**	
Luftvejledningens grænseværdier:													
CO: max 75 mg/m^3_n			**NO_x:** **Anlæg før 2001:** max 125 mg/m^3_n					**Anlæg efter 2001:** max 65 mg/m^3_n				**(alt ved 10% O_2)**	
CO: max 115 ppm			**NO_x:** **Anlæg før 2001:** max 115 ppm					**Anlæg efter 2001:** max 60 ppm				**(alt ved 0% O_2)**	

Figure 6. Excel spreadsheet for adjusting forced draught burners.

This example is the same as above. With tip-point at 1 % O_2 the adjustment point is 4.1 % O_2, and with 0.9 % at tip-point the adjustment point is 4 % O_2. As a bonus, this diagram also tells the installer if the emissions from the burner system at the set-point fulfil the limits of the Danish air emission guidelines. The field turns orange or red if not fulfilled.

Web application

Finally, the same method has been coded for smart phone use or iPad/tablet. Just use the QR-code below and install it on your smart phone. This web application has the same facilities as the excel spreadsheet. The cases at the consumers (data for the boilers) can be stored on the smart phone and opened for later use or control. See Figure 7.

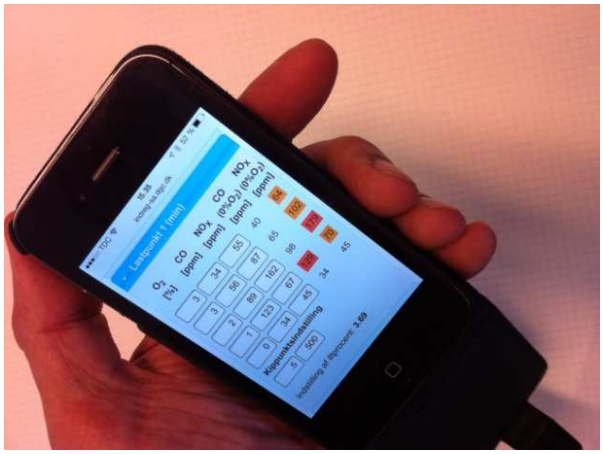

Figure 7. Adjustment of forced draught burners using smart phone.

Conclusions

Since October 2010, part of the Danish natural gas supply is imported from Germany. As a consequence, customers receive two distinctly different gas qualities, and Wobbe Index variations up to 8 % are now commonly observed. The transition to a more flexible gas supply was carefully prepared by a task force led by the Danish TSO and with participation of all DSOs and Danish Gas Technology Centre. Due to this work, the transition did not cause any major problems for the customers; only few problems with noise from gas appliances and performance problems at CHP plants occurred.

More than a thousand installers of the appliances were instructed in new methods of adjustment of boilers and burners adapted for the new conditions of quality variations up to 10 % in contrast to previously 1 % variation in the Danish natural gas system. Different methods apply for different appliances including use of spreadsheets and smart phone applications.