Joint Gas Distribution Network (GDN) Response to the Energy UK Gas Retail Group Study into the effect of shrinkage on domestic customers

1. Introduction

The Energy UK Gas Retail Group (GRG) submitted a report authored by Imperial College Consultants LTD (ICC) to the Gas Distribution Networks (GDNs). The intention of this submission was to be a representation to the 2015 annual review of the Shrinkage and Leakage model (SLMR). However due to the timing of the submission and the level of detail included further time to fully consider and respond to this report outside of the consultation process was warranted.

Since meeting with GRG in May, the GDNs have now had the opportunity to review the report in detail, meet with the authors to further understand some of the detail contained therein and thus fully consider the conclusions it draws. The GDNs therefore now find themselves in position to formally respond.

Given the length of the report (124 pages), this response focuses on the Executive summary, the key findings at the end of each chapter and the main conclusions and recommendations.

2. Executive Summary

The *Energy UK Gas Retail Group Shrinkage Study*[1], (henceforth referred to as *'the report') is* a report that was commissioned by the GRG to "review the methodology used to calculate gas shrinkage and assess whether it needs updating or improving". The report makes reference to "requiring the cooperation of the of Gas Distribution Networks", but it should be noted that the GDNs were not invited to be involved nor were they consulted at any stage of the process, only being aware of the report when it was submitted for response. In the GDNs opinion it is felt that this is to the detriment of the document as it has resulted in some assumptions and conclusions that are either not entirely valid, or, in some cases, not accurate. However, the GDNs appreciate the effort which has gone into preparing this report. It provides a good reference to other methods of measuring leakage in other countries and has also identified some potential opportunities to consider in addition to the work GDNs are already undertaking to improve the accuracy of the leakage model. The core recommendation of the report is that the National Leakage Tests (NLTs), upon which the Shrinkage and Leakage model is built, should be re-performed to 're-calibrate' the model. The justification for this recommendation is largely based on the length of time since the last tests were undertaken (conducted in 2002-3) and a comparison of the UK leakage rates against those of other countries. Having reviewed the evidence presented in the report the GDNs conclude that :-

- the leakage assessment methodologies presented, are not as accurate as the methodology used in UK
- the alternative rates from other countries used for comparisons cannot be compared to the UK without some normalisation of key drivers e.g. pressure ranges or operational regimes.

[1] IC **Consultants** Ltd, October 2015, *Energy UK Gas Retail Group Study into the effect of shrinkage on domestic customers - Version 5*, **[Online], Available:** **http://www.gasgovernance.co.uk/sites/default/files/GRG%20shrinkage%20study%20FINAL.pdf**

Indeed the evidence contained within report and additional investigation into the sources presented has reinforced the belief that the methodologies utilised for shrinkage and leakage assessment in the UK are valid.

The GDNs do, however, recognise that there are arguments both for and against re-doing the NLTs and as such will commit to consult with their wider stakeholder groups and, based on feedback, consider the inclusion of new leakage tests within their RIIO-GD2 business plans.

The GDNs are also committed to continuous improvement of the UK model and are in the process of exploring some of the methodologies highlighted in the report with a view to further improving our own assessment.

3. Responses to Conclusions and Key Findings from individual sections

3.1. Overview of the Shrinkage and Leakage Model

Section 3 of the report deals with the Shrinkage and Leakage Model (SLM) and the constituent components. This review of the SLM was conducted independently from the GDNs and, consequently, has resulted in some incorrect assumptions and references to out of date materials leading to conclusions and recommendations that, in some cases, are not valid. Many of the conclusions and key findings within Section 3 of the report follow a common theme and these are commented on in the sections below.

3.1.1. Joints, corrosion and the mechanisms of metallic leakage

The report frequently makes reference to how the leakage rates contained within the Shrinkage and Leakage model 'contradict physical laws'. Unfortunately this conclusion is only valid if it is assumed that the leakage from mains is uniform around the circumference of the pipe barrel. Indeed it is suggested that "for all sizes of ductile iron main, the dominant failure mode is likely to be through wall corrosion". In practice through wall corrosion is rarely discovered to be the cause of gas leaks, with by far the most common cause being leakage at the joints between pipe sections. When such joint failures occur it is likely that that the leak is the result of a number of small, discrete leak paths, as opposed to the whole joint failing. Therefore, it cannot automatically be concluded that the leakage will be proportional to the pipe diameter.

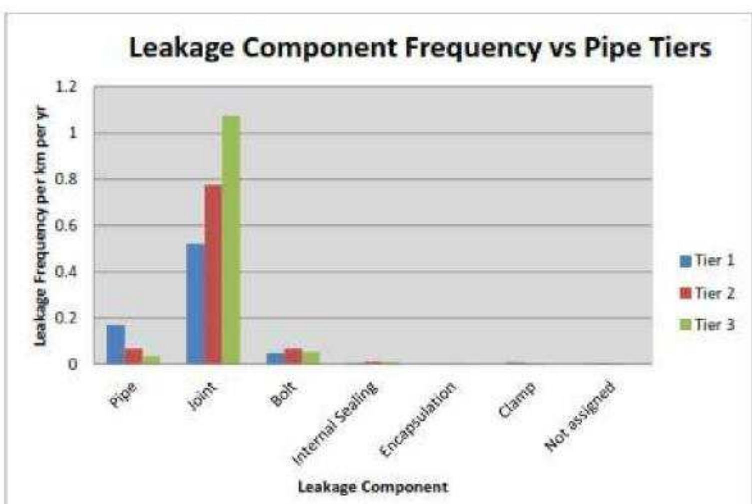

Figure 1: Excerpts from "Cast Iron Fitness for Purpose" innovation project whereby failure data provided by all GDNs has been compiled to identify the main causes of leaks on iron mains.

It is acknowledged that corrosion of the pipe barrel can be and is a cause of failure. However investigation of corrosion on cast iron mains (in particular pit and spun cast mains) has shown that when corrosion does occur it is often very localised in the form of pitting and it does not occur uniformly around the pipe. In addition, as pipe diameter increases so does the wall thickness of the pipe. Consequently, the risk of through wall corrosion occurring is reduced as the pipe diameter increases.

3.1.2. PE leakage, leakage rates and services

3.1.2.1. PE Service Leakage Rate

The report on a number of occasions makes reference to PE services having zero leakage rates in the shrinkage and leakage model, which is not correct.

Service leakage is applied based on the combination of service material as well as the material of the main is it connected to. As such there are four service leakage rates, these are as follows:

1. PE service connected to a PE main
2. PE service connected to a metallic main
3. Metallic service connected to a metallic main
4. Metallic service connected to a PE main.

Whilst it is true that two out of these four categories have zero leakage rates applied within the shrinkage and leakage model, these two categories are for services connected to PE mains (PE service connected to PE main and metallic service connected to a PE main). A PE service on a metallic main is in fact attributed with a leakage rate.

Furthermore, whilst the two categories PE to PE and metallic to PE, have been attributed zero leakage rates this does not necessarily mean that there is an assumption that these services do not leak, rather the way any such leakage is attributed within the model is different. To understand this it is necessary to understand the process by which these leakage rates were determined as part of the 2002/3 study. As such what follows is a brief explanation of the methodology used to determined service leakage, further detail of the study methodology will be given in the next section.

The 2002/3 national leakage test programme determined leakage rates by isolating sections of mains, re-pressurising these sections and then measuring the pressure decay from these mains over a set length. This was done using two tests - the first test was conducted with the services still attached to the main and would therefore provide a combined leakage rate for mains and services. For the second test the services were disconnected from the main and the main was re-pressurised and the pressure decay test repeated providing a mains only leakage rate. The mains only leakage rate was then subtracted from the combined leakage rate and the difference was therefore attributed to the connected services and formed the service leakage rates. In all cases where the mains material was PE the combined mains and services leakage rate was found to be so low it would have not been possible to accurately separate the mains and services leakage components. In these cases all the leakage was attributed to the main only.

3.1.2.2. Permeation from PE mains

The report makes some reference to permeation of methane through PE mains and services, in turn creating estimates of loss rates through permeation greater than the leakage rates currently included within the SLM.

Having reviewed the documentation and sources provided in the report, the GDNs feel that the assessment of the potential permeation losses are fundamentally flawed. The vast majority of PE within the UK distribution systems is contained within the Low Pressure networks with pressures ranging from 21-75 mbarg with an average of around 30 mbarg and generally operating around 5°C. All the sources of permeation rates of methane in polyethylene quoted in the report were from tests conducted at pressures well in excess of this, usually between 1 barg and 130 barg and usually at elevated temperatures i.e. pressures 30 – 1700 times greater and temperatures significantly higher than in service mains and services would be expected to see. Whilst the GDNs do not discount the possibility that there are permeation losses from these mains, it is their belief that the permeation rates included within the report, which are a straight extrapolation of the data points described above, are significantly in excess of what would actually be expected in practice.

In addition to the above it should also be noted that the calculation of permeation loss rates included within the report are based on the assumption that pressure within pipes increases as the diameter increases. This is not the case, if anything having larger mains and services allows the network pressure to be maintained at a lower value for a given demand.

3.2. Other evidence in the international literature: leakage estimates, measurements and policies

Section 4 of the report provides an overview of leakage rates and leakage rate estimation methodologies from other countries around the world and attempts to compare them to the equivalent UK leakage rates.

Upon investigation of the sources of these comparisons specifically, that of the US and Netherlands, it is quite clear that neither of these studies come close to the volume and detail of the tests undertaken in the 2002/03 National Leakage Tests and are significantly different in their approach.

The studies themselves also recognise their own limitations although this is not made apparent in the report; an expected error of ±65% in the case of the US study and the Netherlands study did not "intend[ed] to obtain full statistically reliable leakage data, but to gain insight into the order of magnitude".

The review of these alternative studies into leakage rates has provide the GDNs with valuable insight into the techniques used for leakage rate determination in other countries. However the GDNs remain confident that the results of the 2002/3 National Leakage Tests remain valid and thus retain confidence in the rates that were produced as a result. This evaluation of the NLTs is even mirrored in one of the referenced sources within the report[3] (discussed further during consideration of the Spanish Tests).

---

[3] http://members.igu.org/html/wgc2006/pdf/paper/add9930.pdf

A brief comparison of the different leakage tests conducted is tabulated below.

Test	Cast Iron	Spun Iron	Ductile Iron	Steel	PE	Mains Total	Services	Confidence
2002/3 NLT	445	139	111	62	92	849	6054	90% confidence interval as a percentage of total value: ±19.4%
Netherlands 2005	7		3	3 LP 4 HP	0 LP 3 MP	13	0	"not intended to obtain a full statistically reliable leakage data"
US EPA Tests 1996	21			17	6 (described as 'plastic'	44	33	±65%
Spanish Tests 2005	0				21 (34 test 13 dis-counted)	21	Unspecified	90% confidence level as a percentage of total value: ±47.8%

In order to understand why this is the case each of the different techniques must first be understood.

3.2.1. 2002/3 National Leakage Tests

The 2002/3 National Leakage Tests describe the tests that were conducted across the UK to refresh the leakage rates that had been generated by the 1992 National Leakage Tests. The objectives of the 2002/3 NLTs are quoted as follows:

I. The test programme should establish leakage rates for the distribution mains and service populations, with the total leakage estimate having a 90% confidence interval of ±10% around the mean value.
II. The samples tested should be statistically sound and representative of the overall system population
III. The methodologies used and results obtained should provide a credible and reliable estimate of leakage, which can be readily verified by independent audit.

The NLT utilised the pressure decay method to test 849 samples (each between 80 and 120 m in length) to generate leakage rates for 11 different strata of material and diameter combinations for mains and 4 strata for services. A separate exercise was also undertaken in 2003 to establish leakage rates for 5 different types of Above Ground Installations (AGIs) and involved testing at 536 AGIs.

3.2.2. The Netherlands Leakage Study[4]

The Netherlands study that was referenced in the report dates from 2006 and details the tests conducted in 2005. The Netherlands undertook to move from an IPCC Tier 1 estimate of emissions to

[4] http://members.igu.org/html/wgc2006/pdf/paper/add10963.pdf

an IPCC Tier 3 estimation technique (i.e. moving from using % of natural gas supplied to estimates based on source specific emissions factors). The leakage rates in the Netherlands were determined by identifying actual leaks via leakage surveys and using a suction method to determine the leakage rate from each leak. The results from these tests are provided below.

Material	Average	(Min-Max)	No. of locations
	[litres nat.gas/hour]		
PVC (Unmodified and High Impact) – low pressure	180	(1.6-580)	5
Grey cast iron – low pressure	110	(4.6-350)	7
Steel – low pressure	20	(11-32)	3
Ductile cast iron – low pressure	160	(96-231)	3
PE – medium pressure	270	(22-690)	3
Steel – high pressure	170	(55-461)	4

Figure 2: Results from leakage tests in the Netherlands

As can be seen from these results only 25 tests were conducted across the whole of the Netherlands and only five combinations of materials and pressure tiers were tested. It can also be seen from these results that there is significant variation within the results – low pressure PVC for example was found to have leaks with leakage rates varying from 1.6 l/h to 580 l/h (from 5 leaks). This suggests that there is significant uncertainty included within these results, indeed the Netherlands report indicates "It was not intended to obtain a full statistically reliable leakage data, but gain an insight into the order of magnitude".

Furthermore, it is important to note where materials and pressure ranges were not covered by the tested ranges the results were extrapolated to cover these materials and pressures. As such LP PE, which was not tested as part of the Netherlands test, has had the leakage rate of LP PVC attributed to it. It is this leakage rate the report quotes as a point of comparison and justification for retesting UK PE mains. The GDNs feel that this comparison is neither valid nor appropriate. Similarly across all pressure ranges and materials the GDNs do not consider the Netherlands tests to be of sufficient accuracy, nor at a sufficient level of granularity (material types and diameters) to allow for direct comparison.

Finally, the impact of the Netherlands leakage tests and the resulting move from an average % of throughput to an assessment based on 'actual' leakage from the network has reduced overall leakage from around 0.6% of throughput (similar to the UK) to around 0.08% of throughput. Applying the Netherland's leakage to the UK SLM would reduce assumed emissions overall by an average of around 40%.

3.2.3. US EPA Leakage Rates[5]

Other leakage rates the report uses for comparison come from the US EPA report. The process by which these are derived is similar to the methodology utilised in the Netherlands whereby a number of actual leaks are identified on the network and the volume of gas escaping these leaks is then measured. Information on the average number of leaks per unit length is then utilised to determine average leakage rates. The US appears to have conducted more tests than the Netherlands however

[5] https://www.epa.gov/sites/production/files/2016-08/documents/9underground.pdf

these are still limited in overall numbers (64 mains samples and 46 service samples, see Figure 3) with no differentiation for different diameters or granularity when it comes to pressure.

The US surveys however were slightly different to the Netherlands in that they appear to have conducted tests similar to that of the NLTs (albeit on a much smaller scale) for iron mains due to the volume and frequency of leaks they found on mains of this material. Even so these tests were once again limited by overall length.

TABLE 7-1. SUMMARY OF THE NORTH AMERICAN LEAK MEASUREMENT DATA

Pipe Use	Pipe Material	Sample Size	Average Leak Rate, (scf/leak-hour)[a]	90% Confidence Interval, (scf/leak-hour)[a,b]
Mains	Cast Iron	21	0.0093[c]	0.0053[c]
	Unprotected Steel	20	6.45	5.61
	Protected Steel	17	2.55	2.01
	Plastic	6	12.45	19.81
Services	Unprotected Steel	13	2.50	2.46
	Protected Steel	24	1.15	0.62
	Plastic	4	0.37	0.51
	Copper	5	0.94	0.62

[a] Leak rate of natural gas (not adjusted for methane content or soil oxidation).
[b] 90% confidence interval around the mean value (upper bound minus the mean).
[c] scf/foot-hour.

Figure 3: Sample numbers for the US Leakage Study

3.2.4. Spanish Leakage Rates

The report also makes significant comparison to Spanish leakage rates. The Spanish assessment utilised a pressure variation method which they themselves describe as the "best compromise between reliability and cost"[6] having previously made a very useful comparison of the alternative assessment methodologies. The suction method as utilised in the Netherlands was identified as potentially containing significant uncertainties due to the "many sources of error inherent in the method". The bagging method utilised in the US was found to be more reliable than the suction method however still suffered from the disadvantage of having to identify leak locations in the first instance. Conversely, the pressure decay method utilised in the 1992 and 2002/3 NLT is "considered one of the more reliable methods for estimating gas emissions", with the main disadvantages being identified as the cost of implementation and the fact that customers would need to be interrupted during the test.

The pressure variation method works on the principle that the leakage flow rate will be proportional to the pressure of the gas network whereas consumer consumption is not related to the pressure in the main. Therefore the pressure in the network under test is varied over a period of time and the differences in the gas flow rate through the network at these different pressures is utilised to

[6] http://members.igu.org/html/wgc2006/pdf/paper/add9930.pdf

estimate the leakage. This method is reliant on the assumption that actual consumer consumption remains constant throughout the test period. The report on the Spanish tests identify this as a significant potential source of error however note that Spain's fairly unique pattern of consumption allow for this type of testing to be conducted and identify that "the pattern of consumption in countries of Southern Europe is, however, very different to those found in Germany or UK" and thus such testing would not be applicable in these countries. The referenced Spanish test report conducted tests on 34 sites with 38% (13) of these being disregarded from the results, most of these due to flows being too high.

3.2.5. Direct Measurement of Leakage Volumes

The report makes reference to a number of studies that have attempted to actually sample local atmospheric concentrations of methane in order to directly measure leakage from the gas network. The GDNs recognise that direct measurement would be the ideal and as such have further investigated the techniques mentioned, including consultation with National Grid's US operations who were directly involved in trialling some of these methods. The devices used in the US trials identified issues with accuracy, in that nearly every airborne methane molecule was being found. For accuracy, devices are required that could differentiate between methane and ethane to allow the source to be identified as fossil based natural gas and not biogenic natural gas (for example, livestock, farms, sewers and landfills). Identification of leaks using this method could lead to unnecessary investigations and disruption to customers as field operatives search for the source of leaks that turn out to not be natural gas related. The GDNS will therefore continue to monitor the alternative options for direct measurement of emissions from the networks, however they still consider use of the leakage rates as determined through the NLTs to be the most effective option for the assessment of leakage volumes.

3.3. Learning from other Industries

The report makes reference to how leakage is assessed in other industries such as the water industry and offshore oil and gas industries.

3.3.1. Comparison to the Water Industry

The GDNs have already looked to review the potential to apply water industry best practice in order to identify, measure and minimise leakage through an innovation project comparing best practice across both sectors[7]. The findings of this report identified that the water industries practices were either already being utilised within gas networks (such as pressure management), similar solutions were in development (in-pipe leak location technology e.g. Visual & Acoustic Leakage Detection[8]) or were simply not feasible to deploy on the gas network (such as district centred metering). It should also be noted that water industry 'economic levels of leakage' are generally accepted to be in the 10's of percent compared to the 0.5% the GDNs suffer. This 'economic level of leakage' approach by the water industry means that in some instance leaks go un-repaired for a significant length of time whereas the GDNs will look to enact a repair as soon as is practicable after detection.

[7] http://www.smarternetworks.org/Project.aspx?ProjectID=1332

[8] http://www.smarternetworks.org/Project.aspx?ProjectID=1208

3.3.2. Comparison to the Offshore Oil and Gas Industry

The description of the actions taken to measure and address leakage on the offshore oil and gas industry is, unsurprisingly, very similar to the measures already taken for the onshore industry, however due to the potential hazard posed to consumers, leaks detected on the distribution networks will be address far more quickly than the '48 hours to 15 weeks' of the off shore industry. It should also be noted that the bagging technique described for leakage quantification is very similar to the technique utilised to assess leakage for AGIs within the SLM. The GDNs are also already utilising similar leakage detection techniques however utilise to higher levels of accuracy, detecting down to 'parts per million' rather than just LEL.

4. Conclusion

The GDNs have reviewed the Gas Retail Group study into the impact of shrinkage on domestic customers and have addressed and clarified some of the key findings from the report. Based on the review of the report and the source material referenced, the GDNs believe that the current methodology and leakage rates utilised within the SLM remain valid and the most accurate current methodology for assessing shrinkage and leakage.

Each GDN updates its own SLM on an annual basis to reflect the actual asset population within their networks. Due to the nature of the regulatory reporting framework, all updates are subject to significant scrutiny and assurance activities to ensure they are an accurate representation of reality.

The GDNs are committed to ensuring that their assessment of shrinkage and leakage volumes remains accurate and current and will therefore continue to investigate and assess possible alternative methods. The report highlighted the differing techniques used for determining leakage rates and the GDNs will explore these options to determine suitability in future rate validation exercises. The GDNs will also be considering the inclusion of age factors for assets in the future development of the SLM. The GDNs are reviewing a number of areas that could contribute to the further improvement of accuracy in shrinkage modelling, for example assessing the medium pressure calculation to determine if a system pressure correction is appropriate, reviewing the own use gas assumption based on outputs from the low carbon trials on pre-heating equipment, reviewing the calculation for theft of gas and reviewing the assumptions for interference damage and remediated pipes.

The GDNs continue to consult with stakeholders to continually develop the SLM, to further increase the accuracy and confidence we have in the model.