

Summary of Results

External Quality Assessment for: *Legionella* Isolation from Water Samples

Distribution Number: G66
Sample Numbers: G66A, G66B, G66C

Distribution Date:	June 2009
Results Due:	10 July 2009
Report Date:	29 July 2009
Samples prepared and quality control tested by:	Morolake Adedeji Zak Prior Thamayanthy Ramesh Vince Smith Anitha Tallam
Data analysed by:	Heena Shah
Report compiled by:	Heena Shah Dr Nicola L. Lang Julie E. Russell
Authorised by:	Julie E. Russell

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Centre for Infections
Food and Environmental Proficiency Testing Unit (FEPTU)

61 Colindale Avenue

London

NW9 5EQ

Tel: +44 (0) 20 8327 7119

Fax: +44 (0) 20 8200 8264

Email: Legionellaeqa@hpa.org.uk

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If you require further information about the scheme, samples, quality control, expected results, allocation of scores or performance assessments please refer to the 'General Information Section' on pages 12 - 14.

Participants are reminded that we allocate scores for results and the purpose of scoring is to draw attention to incorrect or outlying results. Participants who report outlying results for the enumeration of legionellae on single occasions only should not be unduly alarmed although they should still assess the reason(s) for the outlying result.

We also provide a separate report summarising assessment of performance over four distributions to help participants to identify on-going problems with examinations for *Legionella* organisms.

If you experienced problems with any of these examinations please refer to the 'Troubleshooting Section' on pages 10 - 11 and request a repeat sample.

Participants are reminded that incorrect or incomplete identification of *Legionella* spp. from water samples could have serious public health implications.

Similarly, the level of legionellae reported in the sample may affect the subsequent response for the water-source.

Please contact FEPTU staff for advice and information. Contact details are on page 11.

Information about other Health Protection Agency functions and services is available from the web-site www.hpa.org.uk

Sample: G66A

Contents:

Legionella pneumophila sg 3

Expected Results:

	Expected Result	Your Result	Your Score	Comments
Isolation of legionellae	Present			
Identification	<i>L.pneumophila</i>			
Serogroup	2 - 14			
Enumeration	$6.3 \times 10^2 - 2.2 \times 10^4$ cfu L ⁻¹			
		Results returned		
		Total score out of		

Background Flora:

This sample did not contain background flora

Comments on Performance:

Participants' results reported are summarised in Fig. 1 (page 7).

Total participants reporting results	169
Participants reporting correctly the presence of legionellae	161 (95%)
Participants reporting correct identification of <i>L.pneumophila</i>	156 (97%)
Participants not reporting identification of Legionella	1 (1%)
Participants reporting NE (not examined) for identification	4 (2%)
Participants reporting correct serogroup: sg 2 - 14	155 (96%)
Participants reporting incorrect serogroup: species	1 (1%)
Participants not reporting serogroup	1 (1%)
Participants reporting NE (not examined) for the serogroup	4 (2%)
Total participants enumerating legionellae	164
Participants reporting a low censored value	2
Participants' median	4.2×10^3 cfu L ⁻¹
No. of outlying counts	21 (16 low / 5 high)
Participants' mean	3.6×10^3 cfu L ⁻¹
Standard deviation of participants' results	0.42 log ₁₀ unit per cfu L ⁻¹
FEPTU median	2.7×10^3 cfu L ^{-1*}
*Percentage recovery following HT ¹ compared with the UT ³ sample	16%
*Percentage recovery following AT ² compared with the UT ³ sample	67%
*These are FEPTU figures given for guidance only – percentages may differ depending on the method used	
1 Heat Treatment	2 Acid Treatment
3 Untreated	
Total sent sample	200
Non-returns	20
Not examined	11

Sample: G66B

Contents:

Legionella pneumophila sg 6, *Enterobacter cloacae* and *Brevibacterium laterosporus*

Expected Results:

	Expected Result	Your Result	Your Score	Comments
Isolation of legionellae	Present			
Identification	<i>L.pneumophila</i>			
Serogroup	2 - 14			
Enumeration	35 – 1.1x10 ³ cfu L ⁻¹			
			Results returned	
			Total score out of	

Background Flora:

E.cloacae and *B.laterosporus* did form colonies on GVPC medium after processing

Comments on Performance:

Participants' results reported are summarised in Fig. 2 (page 8).

Total participants reporting results	169
Participants reporting correctly the presence of legionellae	132 (78%)
Participants reporting correct identification of <i>L.pneumophila</i>	126 (95%)
Participants reporting incorrectly as not pneumophila	2 (2%)
Participants not reporting identification of Legionella	1 (1%)
Participants reporting NE (not examined) for identification	3 (2%)
Participants reporting correct serogroup: sg 2 - 14	120 (91%)
Participants reporting incorrect serogroup	5 (4%)
<ul style="list-style-type: none"> • Sg 2 (1) • Sg 3 (1) • Sg 5 (1) • Species (2) 	
Participants not reporting serogroup	4 (3%)
Participants reporting NE (not examined) for the serogroup	3 (2%)
Total participants enumerating legionellae	146
Participants reporting a low censored value	12
Participants' median	2.0x10 ² cfu L ⁻¹
No. of outlying counts	20 (12 low / 8 high)
Participants' mean	1.9x10 ² cfu L ⁻¹
Standard deviation of participants' results	0.45 log ₁₀ unit per cfu L ⁻¹
FEPTU median	1.6x10 ² cfu L ^{-1*}
*Percentage recovery following HT ¹ compared with the UT ³ sample	2 %
*Percentage recovery following AT ² compared with the UT ³ sample	120 %
*These are FEPTU figures given for guidance only – percentages may differ depending on the method used	
1 Heat Treatment 2 Acid Treatment 3 Untreated	
Total sent sample	200
Non-returns	20
Not examined	11

Sample: G66C

Contents:

Legionella pneumophila sg 5

Expected Results:

	Expected Result	Your Result	Your Score	Comments
Isolation of legionellae	Present			
Identification	<i>L.pneumophila</i>			
Serogroup	2 - 14			
Enumeration	$8.9 \times 10^2 - 2.8 \times 10^4$ cfu L ⁻¹			
			Results returned	
			Total score out of	

Background Flora:

This sample did not contain background flora

Comments on Performance:

Participants' results reported are summarised in Fig. 3 (page 9).

Total participants reporting results	170
Participants reporting correctly the presence of legionellae	162 (95%)
Participants reporting correct identification of <i>L.pneumophila</i>	157 (97%)
Participants not reporting identification of Legionella	1 (1%)
Participants reporting NE (not examined) for identification	4 (2%)
Participants reporting correct serogroup: sg 2 - 14	154 (95%)
Participants reporting incorrect serogroup	2 (1%)
<ul style="list-style-type: none"> • Sg 3 (1) • Species (1) 	
Participants not reporting serogroup	2 (1%)
Participants reporting NE (not examined) for the serogroup	4 (3%)
Total participants enumerating legionellae	165
Participants' median	4.8×10^3 cfu L ⁻¹
No. of outlying counts	18 (15 low / 3 high)
Participants' mean	4.0×10^3 cfu L ⁻¹
Standard deviation of participants' results	0.45 log ₁₀ unit per cfu L ⁻¹
FEPTU median	3.5×10^3 cfu L ^{-1*}
*Percentage recovery following HT ¹ compared with the UT ³ sample	<1 %
*Percentage recovery following AT ² compared with the UT ³ sample	111 %
*These are FEPTU figures given for guidance only – percentages may differ depending on the method used	
1 Heat Treatment 2 Acid Treatment 3 Untreated	
Total sent sample	200
Non-returns	20
Not examined	10

Legionellae Recovery Comments:

Recognised methods used to enumerate *Legionella* spp. provide only a semi-quantitative estimate of the numbers in environmental water samples. Concentration methods such as those described in ISO documents ISO 11731:1998 and ISO 11731-Part 2:2004 are often used for optimal recovery of *Legionella* but those methods are relatively complex, time consuming and require specialised media and technical skill. For example, the technique described in ISO 11731:1998 requires a number of consecutive stages (filtration, centrifugation, culture, acid and heat-treatment, inoculation, incubation and confirmation) and some legionellae are likely to be lost during some of these stages, such as on the surfaces of membrane and the centrifuge tube. The estimate of the numbers of *Legionella* spp. in environmental samples can be further compromised by the presence and overgrowth of non-legionella background organisms.

Participants are asked to plate out reconstituted samples before processing (pre-sample) in accordance with the instructions provided. **For information, a LENTICULE disc re-hydrated in 10 ml of diluent is a 10⁻¹ reconstitution dilution. A 0.1 ml aliquot of neat reconstitution diluent (≡10⁻¹) and a further 1:10 and 1:100 dilution should be used to inoculate the selective medium.** Numbers of legionellae present in the pre-sample should be calculated using a standard laboratory enumeration method (see below).

$$N = \frac{\text{no. of colonies}}{\text{aliquot} \times \text{reconstituion dilution} (\times \text{dilution})}$$

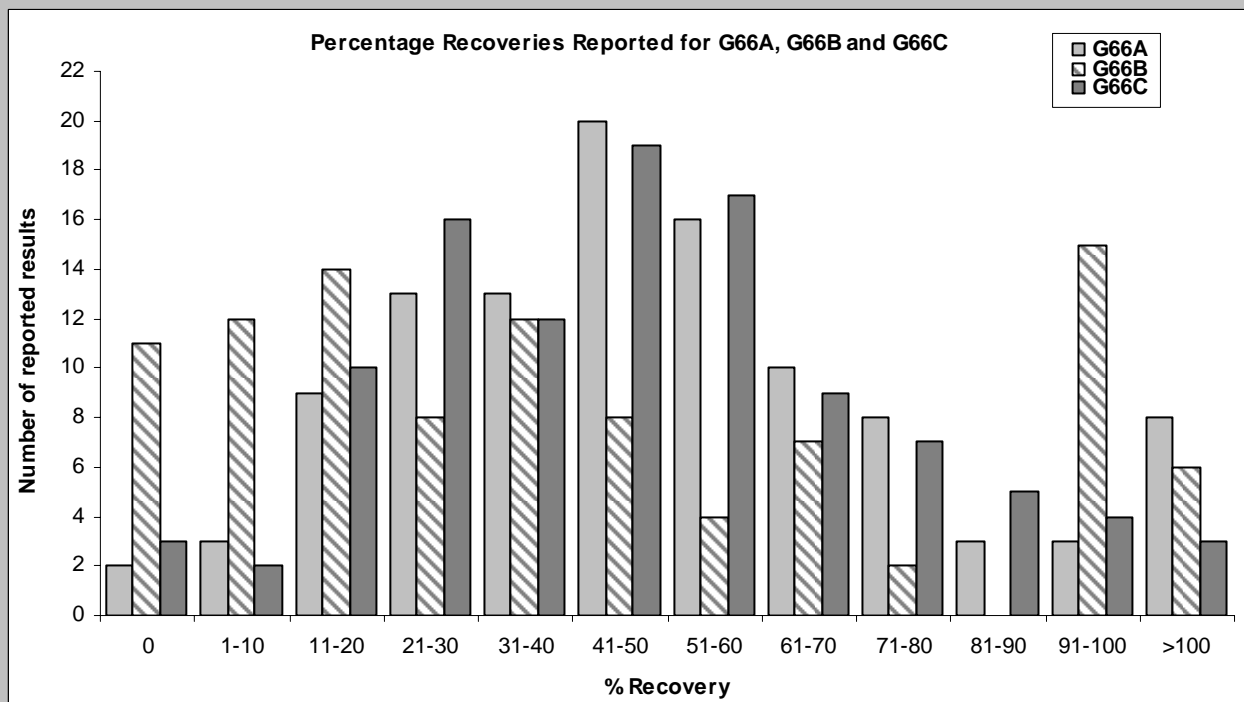
To calculate the percentage recovery (%), the final processed result should be compared with the pre-sample result using a calculation such as;

$$\frac{\text{final processed result}}{\text{pre - sample result}} \times \frac{100}{1}$$

Examples

Data	Pre-sample	% Recovery
48 colonies on neat GVPC plates Process count = 1.2×10^3	$\frac{48}{0.1 \times 0.1} = 4.8 \times 10^3$	$\frac{1.2 \times 10^3}{4.8 \times 10^3} \times \frac{100}{1} = 25\%$
19 colonies on 1:10 GVPC plates Process count = 7.8×10^3	$\frac{19}{0.1 \times 0.1 \times 0.1} = 1.9 \times 10^4$	$\frac{7.8 \times 10^3}{1.9 \times 10^4} \times \frac{100}{1} = 41\%$

A summary of participants' percentage recovery data for G66A, G66B and G66C are shown below. These are only for information to allow participants to assess the recovery of their in-house methods. **Only the final processing results reported are used to assess performance.**

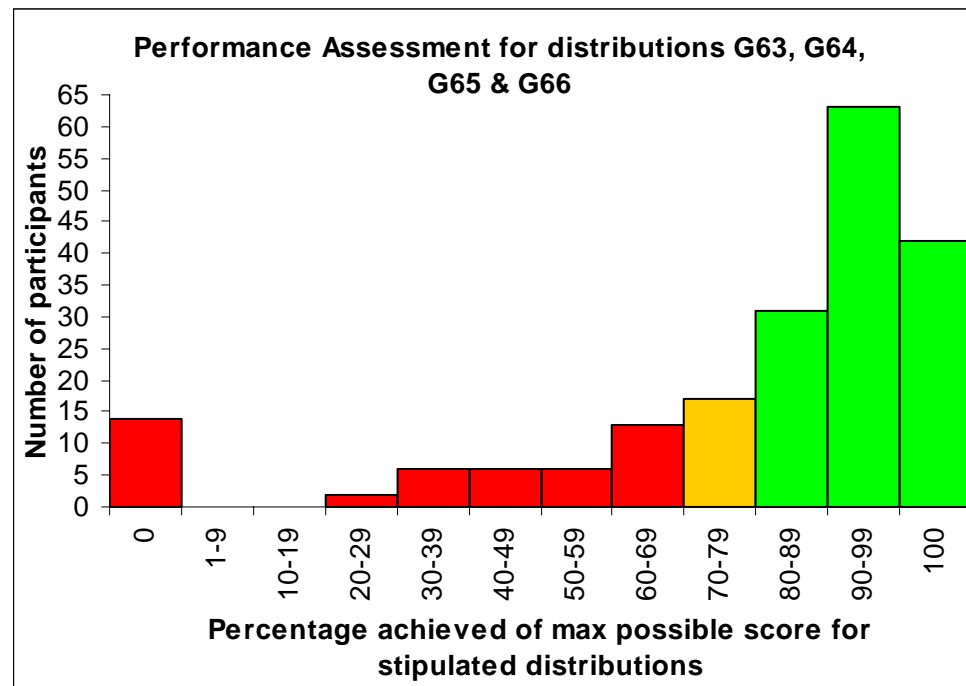


Performance Assessment Sheet

Performance assessments are designed to identify laboratories with on-going problems with their examinations and are undertaken after every distribution. Scores are allocated to results reported for every sample to help assess participants' performance.

Cumulative scores are calculated for every participant, for all examination types, for the current and previous three distributions. Participants' cumulative scores for each of the examination types are compared with the maximum possible scores after every distribution.

Distribution	Sample	Your score	Your %
G63	G63A		
	G63B		
	G63C		
G64	G64A		
	G64B		
	G64C		
G65	G65A		
	G65B		
	G65C		
G66	G66A		
	G66B		
	G66C		



Performance Assessment Comment:

Laboratories that achieve less than 70% of the maximum possible score are likely to be experiencing significant problems with their tests and are advised to a) refer to the relevant sample reports for specific comments b) refer to the HPA website (www.hpa.org.uk/eqa/legionella) c) contact the organisers for advice.

Fig. 1: Log₁₀ Legionella counts reported by participants - sample G66A

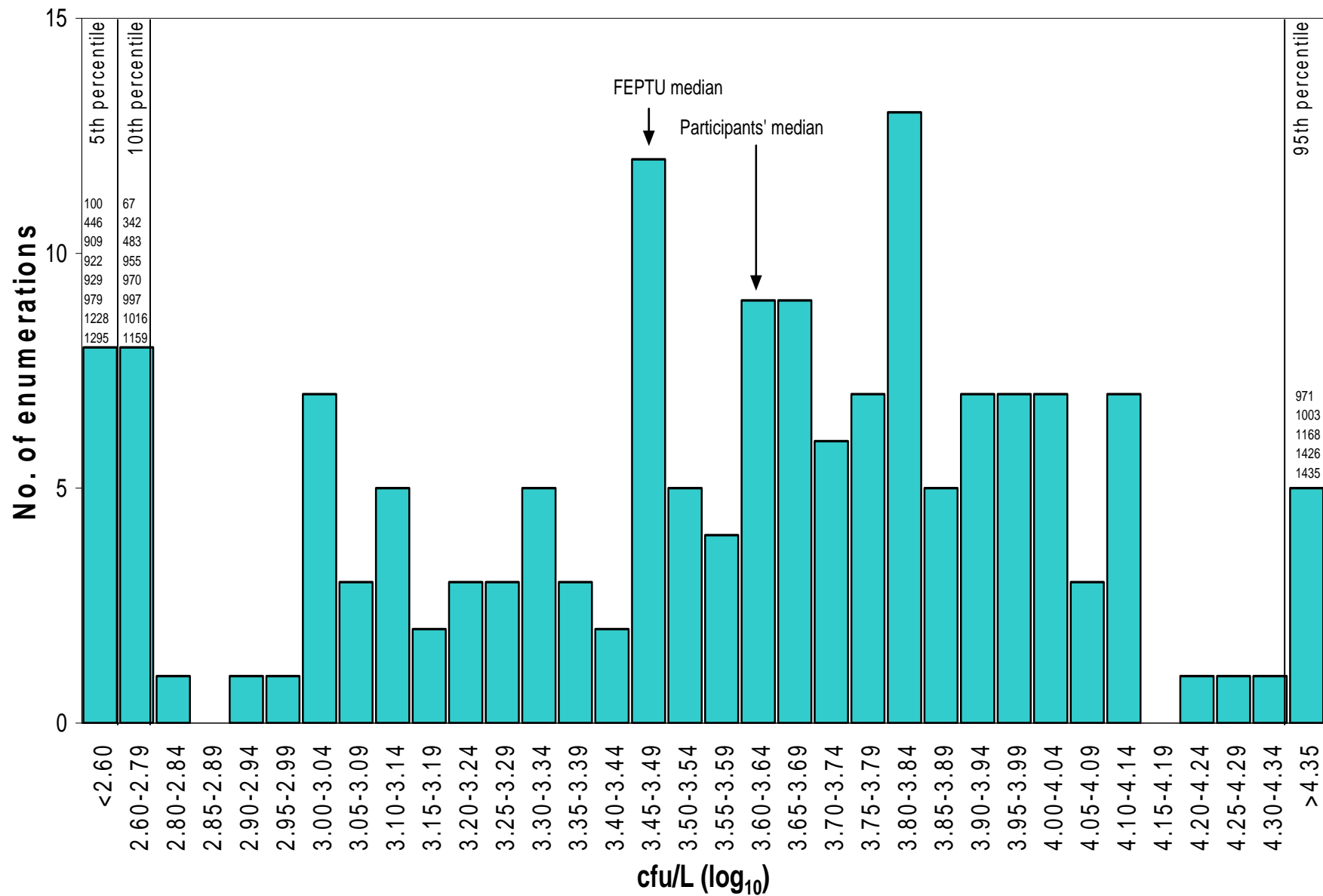


Fig. 2: Log₁₀ Legionella counts reported by participants - sample G66B

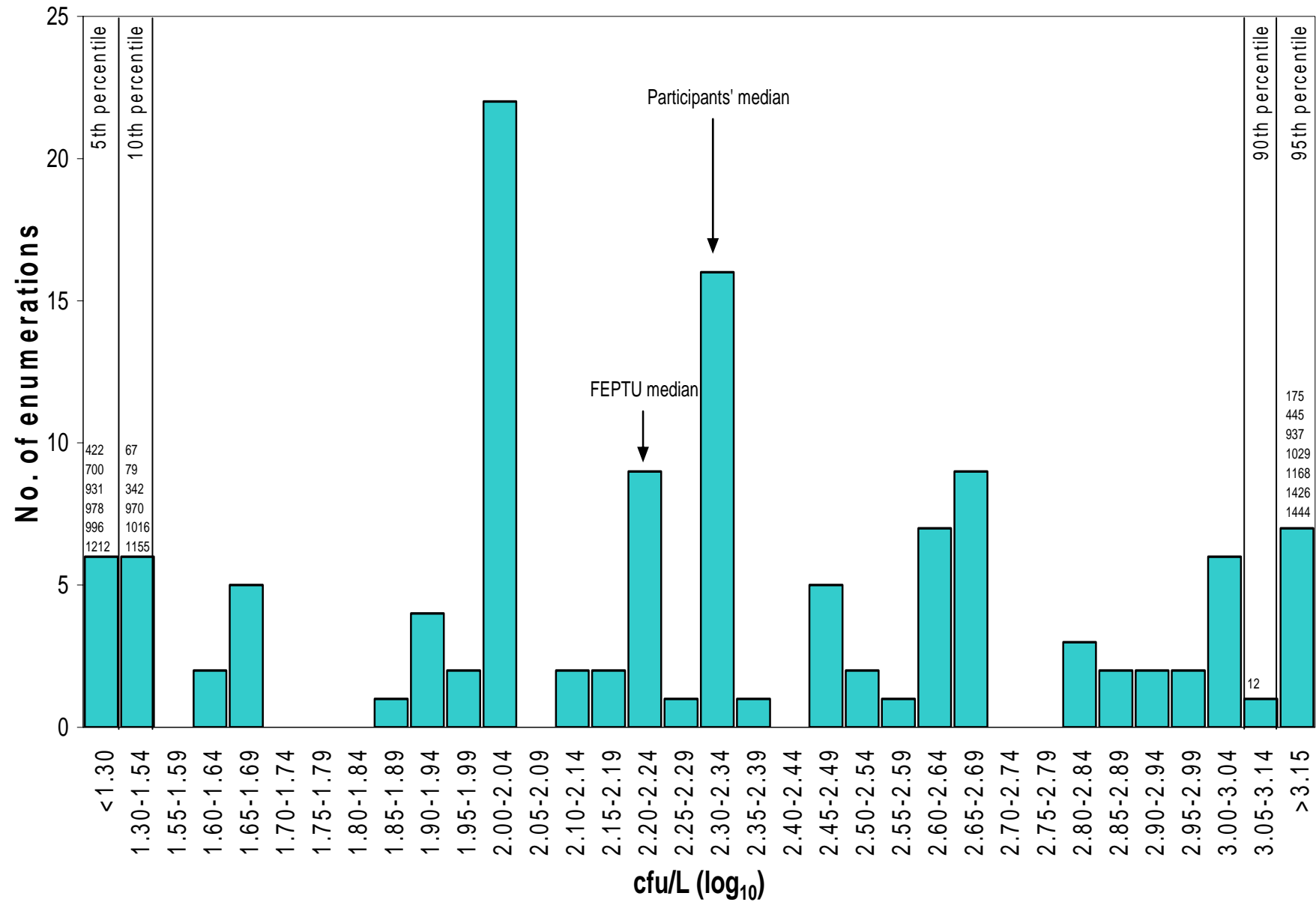
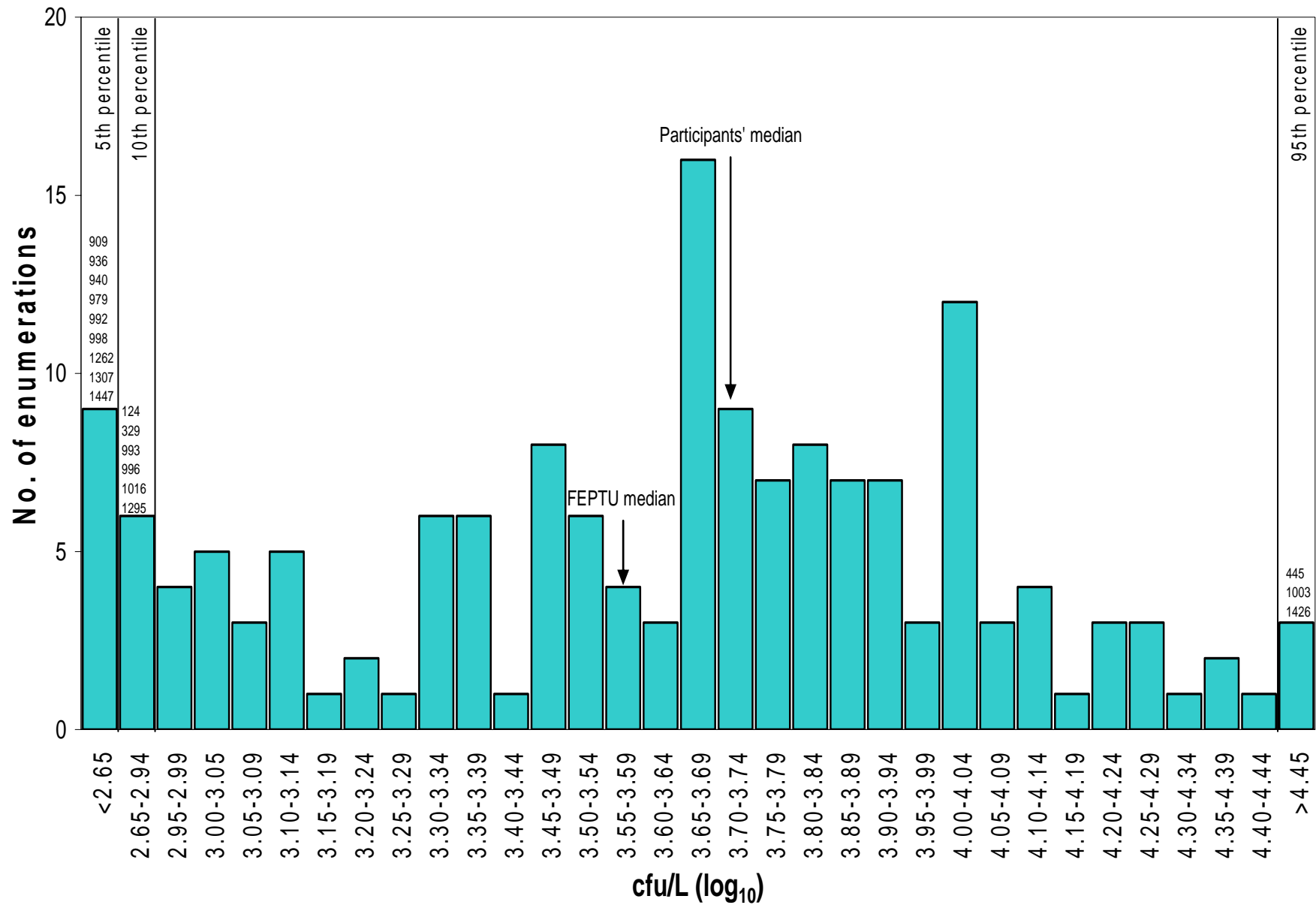


Fig. 3: Log₁₀ Legionella counts reported by participants - sample G66C



Troubleshooting

Checklist for Quality:

- 1. Methods**
Are you using standard or validated, clearly documented methods for isolation, identification and enumeration of Legionella spp.?
- 2. Culture media**
Is your culture media allowing optimal isolation of Legionella spp.? Do you have sufficiently challenging quality control procedures for your culture media?
- 3. Control strains**
Do you use control strains, at appropriate levels, for all the processing procedures?
- 4. Processing**
*Is the percentage recovery of legionellae as expected following heat and acid treatments?
Do you undertake trend analyses for these processes? Are you aware of the limitations of the method used?*
- 5. Equipment**
Is all the equipment used for the procedures (incubators, refrigerators, measuring instruments, waterbaths etc.) calibrated and monitored regularly?
- 6. Staff Training**
Are the staff who perform the examinations fully trained and familiar with all the procedural steps?
- 7. Internal Quality Control (IQC)**
Do you have adequate IQC procedures in place with documented guidelines for dealing with IQC failures?
- 8. Good Laboratory Practice (GLP)**
*Do staff adhere to GLP at all times?
If cross-contamination has occurred with EQA samples it can also occur with routine water samples.*
- 9. Clerical Procedures**
*Are your laboratory numbering and clerical procedures adequate?
If you have reported EQA results incorrectly this may also happen with routine water samples*

Identification of *Legionella* spp.

There are at least 50 species of *Legionella* of which at least 20 have been associated with human disease. The species that is most commonly isolated both from the environment and from infections is *L.pneumophila*; this species can be divided into at least 16 serogroups on the basis of surface antigens. *L.pneumophila* serogroup 1 is the most common cause of outbreaks of Legionnaires' disease and, within serogroup 1, the strains most commonly associated with disease share a common epitope, as revealed by monoclonal subtyping. It is important, because of the risks to human health, to differentiate routinely between *L.pneumophila* and the other *Legionella* species and to be able to distinguish serogroup 1 from the other serogroups of *L.pneumophila*. However, monoclonal subtyping is normally performed only by specialist reference laboratories. Participants who do not identify *Legionella* spp. other than *L.pneumophila* should, where appropriate, report their results as '*Legionella* sp. not *L.pneumophila*' rather than '*Legionella* sp.'.

Incomplete or misleading identification of *Legionella* spp. from water samples may have serious public health implications. Correct reporting of the serogroup is essential for outbreak investigations.

False Positive Results - *Legionella* sp. reported incorrectly as present

False positive results may arise due to cross-contamination, either from other test samples or control strains, mis-identification of background micro-organisms that are present in the sample, or sample-handling and clerical errors. False positive results may result in unnecessary treatment of the water-source with serious financial implications.

False Negative Results - *Legionella* sp. reported incorrectly as not detected

There are many reasons for false negative results including failures with processing, culture media or equipment, insufficiently sensitive methods, inadequately trained staff or sample-handling or clerical errors. False negative results may have serious public health implications.

Outlying Results for Enumerations

Outlying results may be due to errors such as preparation of dilutions, selectivity of culture media, errors in counting, mis-calculation, mis-identification, mis-reporting or sample-handling or clerical errors. Laboratories are advised to investigate the reasons for any anomalous results, particularly if they are occurring repeatedly. Participants who report consistently low levels should audit all stages of their procedure that might allow organisms to be lost, e.g. filtration, centrifugation and pre-treatment. Participants reporting consistently high counts should assess their identification processes but should consider also whether they use methods that differ from those used by the majority of other participants. Incorrect results for enumerations can give a misleading impression of the severity of the risk associated with the sample.

Repeat Samples

Participants should, where possible, determine the reason(s) for mis-identification, false positive and false negative results and outlying counts for enumerations. Repeat samples should be requested to ensure that causes of error have been eradicated. Repeat samples are free of charge, provided they are dispatched with the next distribution of samples. A handling fee will be charged for immediate dispatch.

Help and Advice

The Scheme Organisers will help participants to resolve issues relating to the testing of environmental water samples for *Legionella* spp. Participants should also contact FEPTU to discuss any issues relating to the schemes in general, data analysis or performance assessments.

Contact Details

Repeat samples

Agnes Byron, Nic Day and
Carmen Gomes

Tel: +44 (0)20 8327 7119

Data analysis

Heena Shah or Dr Nicola Lang

Fax: +44 (0)20 8200 8264

Microbiological advice

Dr Nicola Lang or Julie Russell

E-mail: legionellaeqa@hpa.org.uk

General comments and complaints

Dr Nicola Lang or Julie Russell

Scheme Consultant

Dr John V. Lee

General Information

Scheme: Water EQA for *Legionella* Isolation

Sample Type: LENTICULE disc in screw-cap plastic vial (with desiccant)

Safety Data Sheet: Contact the organisers or www.hpa.org.uk/eqa/legionella

Examinations:

Legionella spp. - presence/absence

Legionella spp. - identification (species and serogroup where appropriate)

Legionella spp. - enumeration (semi - quantitative estimation)

FEPTU Quality Control: A minimum of 10 LENTICULE discs, selected randomly from the batch, are examined for *Legionella* spp. at the dilutions indicated on the request/report forms. The Health Protection Agency (HPA) National Standard Method W12, Detection and enumeration of *Legionella* species by filtration and centrifugation, is used to determine the FEPTU results.

The FEPTU enumeration results are analysed statistically and must not show a variation in excess of 0.75 log₁₀ units. The variation is calculated as (2 x standard deviation) for the 10 FEPTU samples.

The FEPTU results are used for guidance in the 'intended results' letters dispatched immediately after every distribution.

FEPTU Trend Analysis: Trend analysis of FEPTU results compared with participants' results for 2008 to 2009 indicates no bias and demonstrates that all FEPTU results fall within ± 0.5 log₁₀ units of the participants' medians.

Expected Results: The expected results for the identification of *Legionella* spp. are determined by the FEPTU laboratory in collaboration with the HPA's Atypical Pneumonia Unit (APU). The APU is accredited by Clinical Pathology Accreditation (UK) Ltd (CPA).

The expected range for the enumeration of legionellae is determined using a percentile method. The use of percentiles is a non-parametric approach appropriate for data that is unlikely to show a normal distribution. Semi-quantitative methods such as those used for estimating levels of legionellae may not show a normal distribution even after the data has been log-transformed.

The expected range for enumeration results is a 'consensus range' determined from results submitted by participants. The reported counts are ranked from lowest to highest, the median count is calculated and the range between the 11th and 89th percentile values is determined. The expected range is defined as the wider range of either i) counts within the 11th to 89th percentiles or ii) counts equivalent to the median ± 0.75 log₁₀ units. This criteria reflects that methods for estimating the levels of legionellae in environmental water samples are complex and only semi-quantitative so are not directly comparable with simple enumeration methods such as aerobic colony counts where narrower criteria may be applied.

The expected range may, on occasion, differ from the 'intended result' initially reported by the FEPTU laboratory. However, the median FEPTU result should be within ± 0.5 log₁₀ units of the participants' median result. An investigation will be undertaken if the FEPTU and participants' medians differ by more than ± 0.5 log₁₀ units and participants will be informed about this in the sample-specific comments.

Results Analysis and Scores: Scores are allocated to participants' results submitted for every sample as follows:

	Points
Return of Report	1
Correct Result	11
Maximum score	12

The purpose of scoring is to draw attention to incorrect or outlying results. Participants who report outlying results for the enumeration of legionellae on single occasions only should not be alarmed although they should still assess the reason(s) for the outlying result. The allocation of scores helps participants to assess their performance with examinations for *Legionella* spp. over time and identify trends in the results that they are reporting.

Samples containing *Legionella* sp.

The points awarded for a correct result for samples containing *Legionella* sp. are allocated as follows:

Result	Points	Maximum Points
Return of report	1	1
Isolation of a Legionellae	2	2
Correct identification of <i>L.pneumophila</i>	2	4
Correct serogroup	2	
Or		
Correct identification of <i>Legionella</i> sp. (not <i>L.pneumophila</i>)	4	
Enumeration within the expected range	5	5
Or		
Outlying result (1)	4	
Or		
Outlying result (2)	3	
Total maximum score	12	12

Enumerations: Scores are allocated for enumeration results by determining the expected range and the percentile values:

Expected range	Median \pm 0.75 log ₁₀ unit or counts within 11 th to 89 th percentiles
Outlying results (1)	Median \pm >0.75 log ₁₀ units and in 6 th to 10 th or 90 th to 95 th percentiles
Outlying results (2)	Median \pm >0.75 log ₁₀ units and in 0 th to 5 th or 96 th to 100 th percentiles

Dealing with Censored Values (< or > Values): It is difficult to assess enumeration results when participants report censored values. The results form that is provided with the EQA samples indicates the dilutions required to help participants obtain a definitive enumeration result.

Scoring of Other Results:

	Points Allocated
Examination not performed (NE)	No score allocated
No results returned	0
Results reported after the specified return date (Late results)	0
<i>Legionella</i> sp. reported incorrectly as present (i.e. false positive result)	1
<i>Legionella</i> sp. reported incorrectly as not detected (i.e. false negative result)	1
Negative result reported correctly for <i>Legionella</i> sp.	12

Results Charts: Bar charts summarising participants' results for parameters requiring enumeration are included where appropriate.

Results Tables: Tables summarising all the results reported by participants are included for every report.

Conversion Table: Results reported for enumerations are transformed to log₁₀ values prior to analysis. A conversion table is included (Appendix 1).

Performance Assessments:

- Designed to identify laboratories with ongoing problems with their examinations
- Undertaken after every distribution and include results from the current and previous three distributions.

Accreditation: The HPA Legionella Isolation EQA Scheme is accredited by the United Kingdom Accreditation Service (UKAS) to ISO/IEC Guide 43-1:1997 through assessment against ILAC G13: 2007.



References:

ISO; International Organization for Standardization (1998). Water Quality – Detection and enumeration of *Legionella*. ISO 11731:1998 BS 6068-4.12:1998

ISO; International Organization for Standardization (2004). Water Quality – Detection and enumeration of *Legionella* Part 2: Direct membrane filtration methods for waters with low bacterial counts BS ISO 11731-2:2004

Please note that ISO 11731:1998 is under revision. The expected date for publication of the revised document, ISO 11731 (Part 1), is 2009.

APPENDIX 1: Conversion Table: cfu L⁻¹ - log₁₀ cfu L⁻¹

cfu L ⁻¹	log ₁₀ cfu L ⁻¹	cfu L ⁻¹	log ₁₀ cfu L ⁻¹	cfu L ⁻¹	log ₁₀ cfu L ⁻¹
1.9x10 ⁰ - 2.1x10 ⁰	0.30	2.4x10 ² - 2.6x10 ²	2.40	3.0x10 ⁴ - 3.3x10 ⁴	4.50
2.2x10 ⁰ - 2.3x10 ⁰	0.35	2.7x10 ² - 2.9x10 ²	2.45	3.4x10 ⁴ - 3.7x10 ⁴	4.55
2.4x10 ⁰ - 2.6x10 ⁰	0.40	3.0x10 ² - 3.3x10 ²	2.50	3.8x10 ⁴ - 4.2x10 ⁴	4.60
2.7x10 ⁰ - 2.9x10 ⁰	0.45	3.4x10 ² - 3.7x10 ²	2.55	4.3x10 ⁴ - 4.7x10 ⁴	4.65
3.0x10 ⁰ - 3.3x10 ⁰	0.50	3.8x10 ² - 4.2x10 ²	2.60	4.8x10 ⁴ - 5.3x10 ⁴	4.70
3.4x10 ⁰ - 3.7x10 ⁰	0.55	4.3x10 ² - 4.7x10 ²	2.65	5.4x10 ⁴ - 5.9x10 ⁴	4.75
3.8x10 ⁰ - 4.2x10 ⁰	0.60	4.8x10 ² - 5.3x10 ²	2.70	6.0x10 ⁴ - 6.7x10 ⁴	4.80
4.3x10 ⁰ - 4.7x10 ⁰	0.65	5.4x10 ² - 5.9x10 ²	2.75	6.8x10 ⁴ - 7.4x10 ⁴	4.85
4.8x10 ⁰ - 5.3x10 ⁰	0.70	6.0x10 ² - 6.6x10 ²	2.80	7.5x10 ⁴ - 8.5x10 ⁴	4.90
5.4x10 ⁰ - 5.9x10 ⁰	0.75	6.7x10 ² - 7.4x10 ²	2.85	8.6x10 ⁴ - 9.4x10 ⁴	4.95
6.0x10 ⁰ - 6.6x10 ⁰	0.80	7.5x10 ² - 8.4x10 ²	2.90	9.5x10 ⁴ - 1.0x10 ⁵	5.00
6.7x10 ⁰ - 7.4x10 ⁰	0.85	8.5x10 ² - 9.4x10 ²	2.95	1.1x10 ⁵	5.05
7.5x10 ⁰ - 8.4x10 ⁰	0.90	9.5x10 ² - 1.0x10 ³	3.00	1.2x10 ⁵ - 1.3x10 ⁵	5.10
8.5x10 ⁰ - 9.4x10 ⁰	0.95	1.1x10 ³	3.05	1.4x10 ⁵	5.15
9.5x10 ⁰ - 1.0x10 ¹	1.00	1.2x10 ³ - 1.3x10 ³	3.10	1.5x10 ⁵ - 1.6x10 ⁵	5.20
1.1x10 ¹	1.05	1.4x10 ³	3.15	1.7x10 ⁵ - 1.8x10 ⁵	5.25
1.2x10 ¹ - 1.3x10 ¹	1.10	1.5x10 ³ - 1.6x10 ³	3.20	1.9x10 ⁵ - 2.1x10 ⁵	5.30
1.4x10 ¹	1.15	1.7x10 ³ - 1.8x10 ³	3.25	2.2x10 ⁵ - 2.3x10 ⁵	5.35
1.5x10 ¹ - 1.6x10 ¹	1.20	1.9x10 ³ - 2.1x10 ³	3.30	2.4x10 ⁵ - 2.6x10 ⁵	5.40
1.7x10 ¹ - 1.8x10 ¹	1.25	2.2x10 ³ - 2.3x10 ³	3.35	2.7x10 ⁵ - 2.9x10 ⁵	5.45
1.9x10 ¹ - 2.1x10 ¹	1.30	2.4x10 ³ - 2.6x10 ³	3.40	3.0x10 ⁵ - 3.3x10 ⁵	5.50
2.2x10 ¹ - 2.3x10 ¹	1.35	2.7x10 ³ - 2.9x10 ³	3.45	3.4x10 ⁵ - 3.7x10 ⁵	5.55
2.4x10 ¹ - 2.6x10 ¹	1.40	3.0x10 ³ - 3.3x10 ³	3.50	3.8x10 ⁵ - 4.2x10 ⁵	5.60
2.7x10 ¹ - 2.9x10 ¹	1.45	3.4x10 ³ - 3.7x10 ³	3.55	4.3x10 ⁵ - 4.7x10 ⁵	5.65
3.0x10 ¹ - 3.3x10 ¹	1.50	3.8x10 ³ - 4.2x10 ³	3.60	4.8x10 ⁵ - 5.3x10 ⁵	5.70
3.4x10 ¹ - 3.7x10 ¹	1.55	4.3x10 ³ - 4.7x10 ³	3.65	5.4x10 ⁵ - 5.9x10 ⁵	5.75
3.8x10 ¹ - 4.2x10 ¹	1.60	4.8x10 ³ - 5.3x10 ³	3.70	6.0x10 ⁵ - 6.7x10 ⁵	5.80
4.3x10 ¹ - 4.7x10 ¹	1.65	5.4x10 ³ - 5.9x10 ³	3.75	6.8x10 ⁵ - 7.4x10 ⁵	5.85
4.8x10 ¹ - 5.3x10 ¹	1.70	6.0x10 ³ - 6.6x10 ³	3.80	7.5x10 ⁵ - 8.5x10 ⁵	5.90
5.4x10 ¹ - 5.9x10 ¹	1.75	6.7x10 ³ - 7.1x10 ³	3.85	8.6x10 ⁵ - 9.4x10 ⁵	5.95
6.0x10 ¹ - 6.6x10 ¹	1.80	7.2x10 ³ - 8.4x10 ³	3.90	9.5x10 ⁵ - 1.0x10 ⁶	6.00
6.7x10 ¹ - 7.1x10 ¹	1.85	8.5x10 ³ - 9.4x10 ³	3.95	1.1x10 ⁶	6.05
7.2x10 ¹ - 8.4x10 ¹	1.90	9.5x10 ³ - 1.0x10 ⁴	4.00	1.2x10 ⁶ - 1.3x10 ⁶	6.10
8.5x10 ¹ - 9.4x10 ¹	1.95	1.1x10 ⁴	4.05	1.4x10 ⁶	6.15
9.5x10 ¹ - 1.0x10 ²	2.00	1.2x10 ⁴ - 1.3x10 ⁴	4.10	1.5x10 ⁶ - 1.6x10 ⁶	6.20
1.1x10 ²	2.05	1.4x10 ⁴	4.15	1.7x10 ⁶ - 1.8x10 ⁶	6.25
1.2x10 ² - 1.3x10 ²	2.10	1.5x10 ⁴ - 1.6x10 ⁴	4.20	1.9x10 ⁶ - 2.1x10 ⁶	6.30
1.4x10 ²	2.15	1.7x10 ⁴ - 1.8x10 ⁴	4.25	2.2x10 ⁶ - 2.3x10 ⁶	6.35
1.5x10 ² - 1.6x10 ²	2.20	1.9x10 ⁴ - 2.1x10 ⁴	4.30	2.4x10 ⁶ - 2.6x10 ⁶	6.40
1.7x10 ² - 1.8x10 ²	2.25	2.2x10 ⁴ - 2.3x10 ⁴	4.35	2.7x10 ⁶ - 2.9x10 ⁶	6.45
1.9x10 ² - 2.1x10 ²	2.30	2.4x10 ⁴ - 2.6x10 ⁴	4.40	3.0x10 ⁶ - 3.3x10 ⁶	6.50
		2.7x10 ⁴ - 2.9x10 ⁴	4.45	3.4x10 ⁶ - 3.7x10 ⁶	6.55