The ICMSF Spreadsheet Tool
Example *Campylobacter* performance

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Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=20, when this criterion was first implemented

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=20, when this criterion was first implemented

What is the performance of this plan for *c*=15 (2020), and *c*=10 (2025)

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=20, when this criterion was first implemented

Performance is defined as the arithmetic mean concentration that is detected with 95% probability for lots with standard deviation = 0.8 log cfu/g

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=20, when this criterion was first implemented

Is it quantitative/qualitative

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=20, when this criterion was first implemented

It is quantitative (limit *m*= 1000 cfu/g)

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=20, when this criterion was first implemented

Is it 2-class ? 3-class ?

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

What was the performance of this plan for *c*=10, when this criterion was first implemented

Is it 2-class (only one limit *m*)

Sampling plan: Process Hygiene

Hygiene criterion *Campylobacter* broilers

Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

Which tab now to select ?

2-class enrichment | 2-class counts | 3-class counts | 3-class mixed

Quantitative, 2-class, $c \neq 0$

Sampling plan: Process Hygiene

Hygiene criterion *Campylobacter* broilers

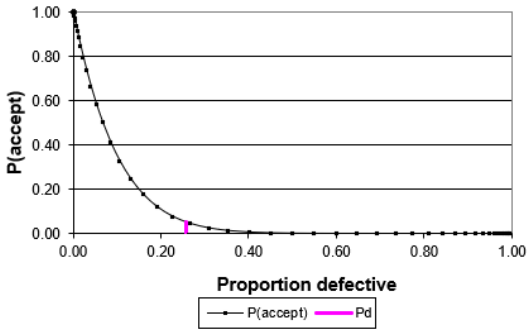
Micro-organism	Sampling plan		*m*	*M*	Analytical method
	n	*c*			
Campylobacter spp.	50	20*	1000 cfu/g	-	ISO 10272-2

* *c*-value increased stringency: 2018: *c*=20; 2020: *c*=15; 2025: *c*=10
EC regulation 2073/2005

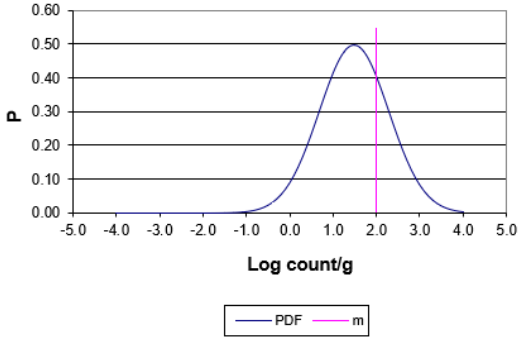
2-class enrichment | **2-class counts** | 3-class counts | 3-class mixed

Quantitative, 2-class, $c \neq 0$

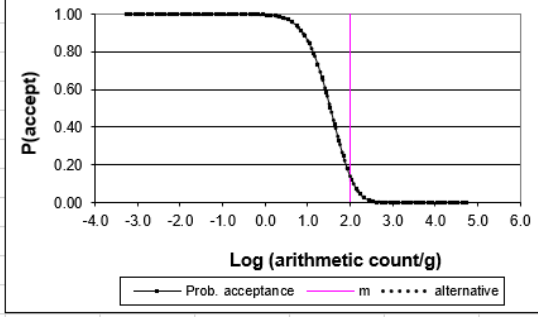
Operating characteristic curve for proportion defective, with n=10 and c=0



Probability density function (PDF) for log counts. Distribution mean = 1.48 and sigma = 0.80



Operating characteristic curve scaled to relate log arithmetic mean count to m



Lot acceptance for Pd			P(accept)	
Pd	10	%	34.9	%
actualPd	25.9	%	5.00	%

INPUTS	
mean	1.48
sigma	0.80
m	2
n	10
c	0

P(accept)		
Computed	5.00	%
Desired	5	%

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject) 95.00 %

ALTERNATIVE n AND c		P(accept)	
mean	1.48	Computed	5.00 %
sigma	0.80	Target, left	5.00 %
m	2		
n	10		
c	0		

For any value of n and c imputed find the m that gives the same P(accept) as the model on the

Sandbox: for your own calculations			
FSO	3		
compliment	0.971076	not comply	0.028924
%	97.10758	%	2.892418

Means			
Arithmetic (=Average)		Geometric (=Median)	
165.7	cfu/g	30.4	cfu/g
2.22	log cfu/g	1.48	log cfu/g

Implied Acceptance level		
Percentile	z-score	Concentration at this percentile
99.9	3.10	3.96
FSO	P(exceedance)	target level
3.96	0.000973	1.482524

This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 30.4 cfu/g and an arithmetic mean concentration of 165.7 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 0 out of 10 samples having higher levels than 2 logs cfu/g)

About | Technical issues | Introduction | 2-class enrichment | 2-class counts | 3-class counts | 3-class mixed | 2-class enrich sensspec | TableSensSpec

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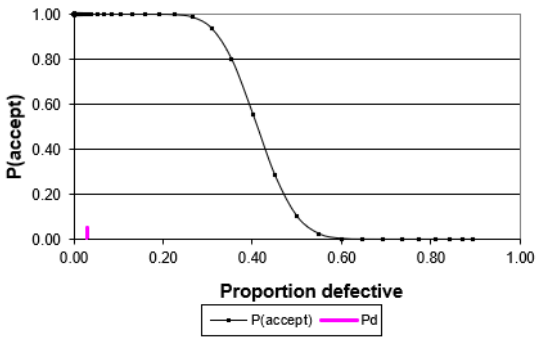
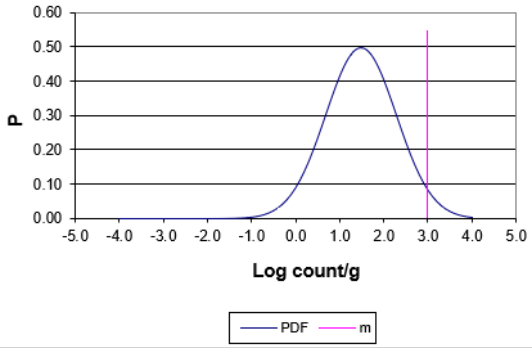
What is the performance (the arithmetic mean concentration detected with 95% probability) for n=50, c=20, m=100 cfu/g for lots with standard deviation = 0.8 log cfu/g?

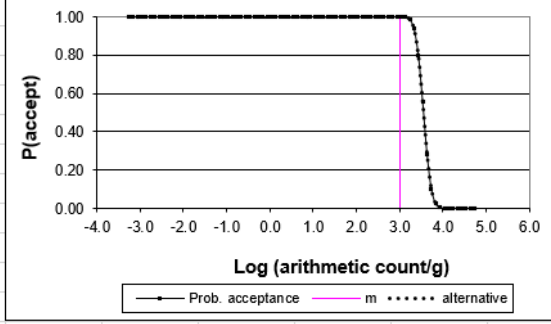
Operating characteristic curve for proportion defective, with n=50 and c=20



Probability density function (PDF) for log counts. Distribution mean = 1.48 and sigma = 0.80



Operating characteristic curve scaled to relate log arithmetic mean count to m



Lot acceptance for Pd			P(accept)	
Pd	10	%	100.0	%
actualPd	2.9	%	100.00	%

INPUTS	
mean	1.48
sigma	0.80
m	3
n	50
c	20

P(accept)		
Computed	100.00	%
Desired	5	%

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject)	0.00	%

ALTERNATIVE n AND c		P(accept)	
mean	1.48	Computed	100.00 %
sigma	0.80	Target, left	100.00 %
m	3		
n	50		
c	20		

For any value of n and c imputed find the m that gives the same P(accept) as the model on the

Sandbox: for your own calculations

FSO	3		
complient	0.971076	not comply	0.028924
%	97.10758	%	2.892418

Means

Arithmetic (=Average)		Geometric (=Median)	
165.7	cfu/g	30.4	cfu/g
2.22	log cfu/g	1.48	log cfu/g

Implied Acceptance level

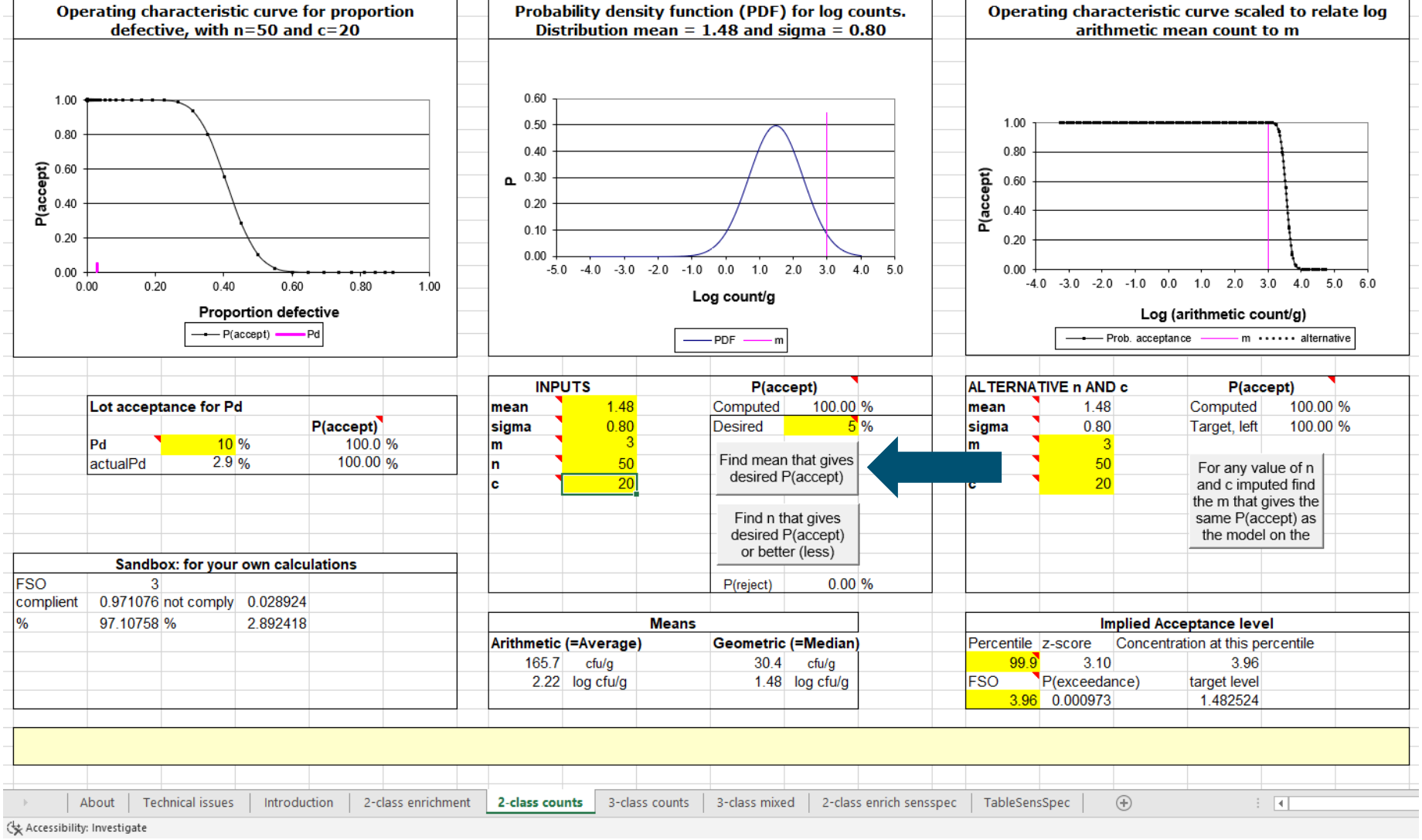
Percentile	z-score	Concentration at this percentile
99.9	3.10	3.96
FSO	P(exceedance)	target level
3.96	0.000973	1.482524

About | Technical issues | Introduction | 2-class enrichment | 2-class counts | 3-class counts | 3-class mixed | 2-class enrich sensspec | TableSensSpec

Accessibility: Investigate

sigma=0.8, *m*=3, *n*=50, *c*=20

Desired P(accept) =5% (95% P(reject))

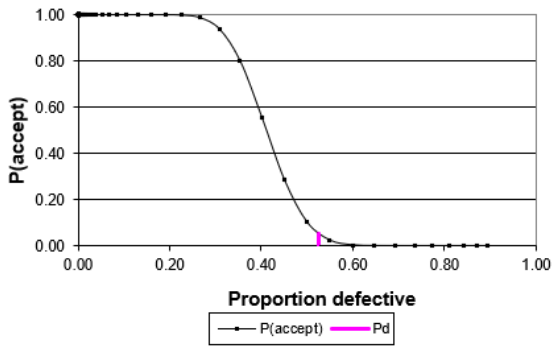


sigma=0.8, *m*=3, *n*=50, *c*=20

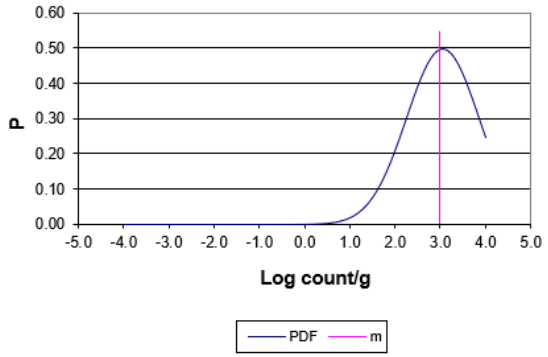
Desired P(accept) =5% (95% P(reject))

Find mean that gives desired P(accept)

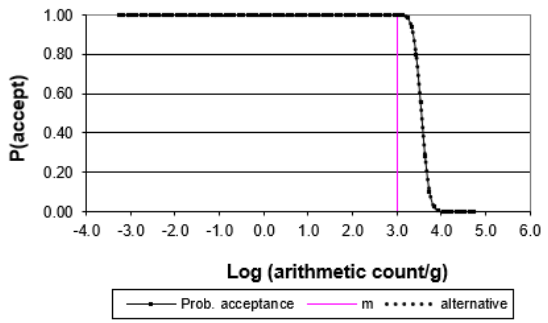
Operating characteristic curve for proportion defective, with n=50 and c=20



Probability density function (PDF) for log counts. Distribution mean = 3.05 and sigma = 0.80



Operating characteristic curve scaled to relate log arithmetic mean count to m



Lot acceptance for Pd			P(accept)	
Pd	10	%	100.0	%
actualPd	52.6	%	5.00	%

INPUTS		P(accept)	
mean	3.05		5.00 %
sigma	0.80	Desired	5 %
m	3		
n	50		
c	20		

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject) 95.00 %

ALTERNATIVE n AND c		P(accept)	
mean	3.05	Computed	5.00 %
sigma	0.80	Target, left	5.00 %
m	3		
n	50		
c	20		

For any value of n and c imputed find the m that gives the same P(accept) as the model on the

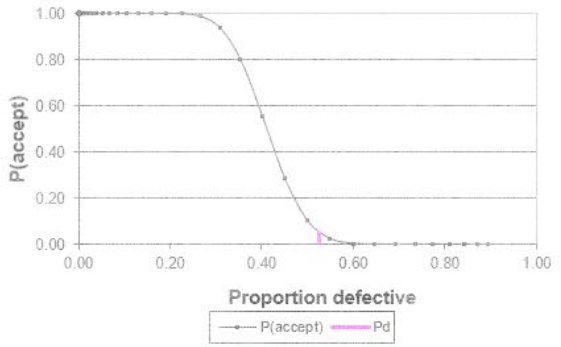
Sandbox: for your own calculations			
FSO	3		
compliant	0.47388	not comply	0.52612
%	47.38798	%	52.61202

Means			
Arithmetic (=Average)		Geometric (=Median)	
6155.2	cfu/g	1128.3	cfu/g
3.79	log cfu/g	3.05	log cfu/g

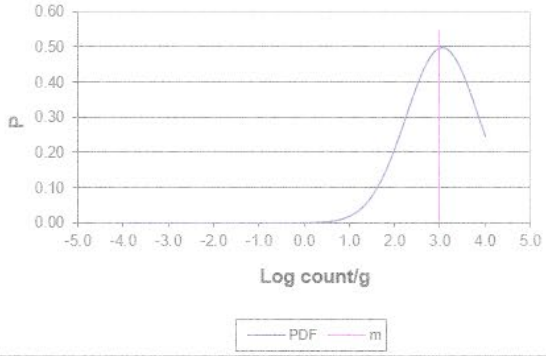
Implied Acceptance level		
Percentile	z-score	Concentration at this percentile
99.9	3.10	5.53
FSO	P(exceedance)	target level
5.53	0.000973	3.052416

This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 1,128.3 cfu/g and an arithmetic mean concentration of 6,155.2 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 20 out of 50 samples having higher levels than 3 logs cfu/g)

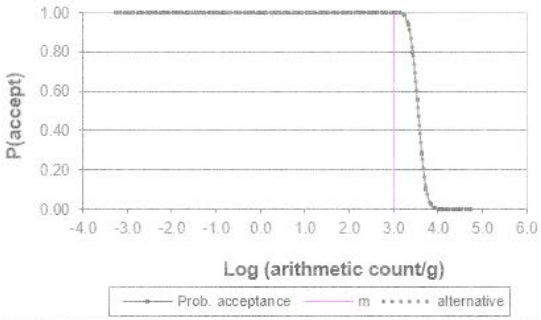
Operating characteristic curve for proportion defective, with n=50 and c=20



Probability density function (PDF) for log counts. Distribution mean = 3.05 and sigma = 0.80



Operating characteristic curve scaled to relate log arithmetic mean count to m



Lot acceptance for Pd			P(accept)
Pd	10	%	100.0 %
actualPd	52.6	%	5.00 %

INPUTS		P(accept)	
mean	3.05	Computed	5.00 %
sigma	0.80	Desired	5 %
m	3		
n	50		
c	20		

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject) 95.00 %

ALTERNATIVE n AND c		P(accept)	
mean	3.05	Computed	5.00 %
sigma	0.80	Target, left	5.00 %
m	3		
n	50		
c	20		

For any value of n and c imputed find the m that gives the same P(accept) as the model on the

Sandbox: for your own calculations			
FSO	3		
complient	0.47388	not comply	0.52612
%	47.38798	%	52.61202

Means			
Arithmetic (=Average)		Geometric (=Median)	
6155.2	cfu/g	1128.3	cfu/g
3.79	log cfu/g	3.05	log cfu/g

Implied Acceptance level		
Percentile	z-score	Concentration at this percentile
99.9	3.10	5.53
FSO	P(exceedance)	target level
5.53	0.000973	3.052416

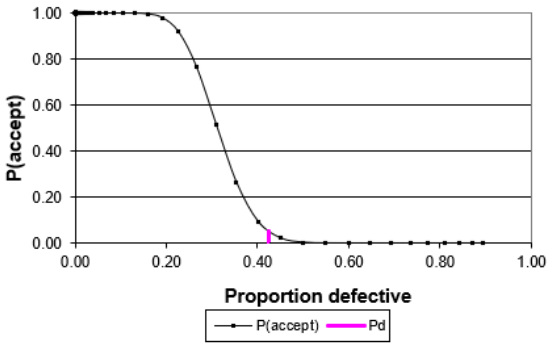
This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 1,128.3 cfu/g and an arithmetic mean concentration of 6,155.2 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 20 out of 50 samples having higher levels than 3 logs cfu/g)

About | Technical issues | Introduction | 2-class enrichment | 2-class counts | 3-class counts | 3-class mixed | 2-class enrich sensspec | TableSensSpec

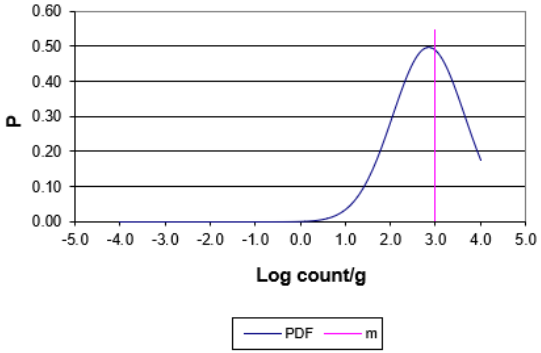
Accessibility: Investigate

This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 1128 cfu/g and an arithmetic mean concentration of 6155 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 20 out of 50 samples having higher levels than 3 logs cfu/g)

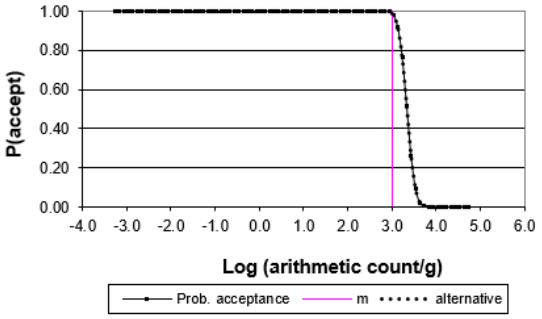
Operating characteristic curve for proportion defective, with n=50 and c=15



Probability density function (PDF) for log counts. Distribution mean = 2.85 and sigma = 0.80



Operating characteristic curve scaled to relate log arithmetic mean count to m



Lot acceptance for Pd			P(accept)
Pd	10	%	100.0 %
actualPd	42.4	%	5.00 %

INPUTS	
mean	2.85
sigma	0.80
m	3
n	50
c	15

P(accept)	
Computed	5.00 %
Desired	5 %

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject)	95.00 %

ALTERNATIVE n AND c		P(accept)	
mean	2.85	Computed	5.00 %
sigma	0.80	Target, left	5.00 %
m	3		
n	50		
c	15		

For any value of n and c imputed find the m that gives the same P(accept) as the model on the

Sandbox: for your own calculations

FSO	3		
compliant	0.576266	not comply	0.423734
%	57.62665	%	42.37335

Means

Arithmetic (=Average)		Geometric (=Median)	
3827.8	cfu/g	701.6	cfu/g
3.58	log cfu/g	2.85	log cfu/g

Implied Acceptance level

Percentile	z-score	Concentration at this percentile
99.9	3.10	5.32
FSO	P(exceedance)	target level
5.32	0.000973	2.846119

This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 701.6 cfu/g and an arithmetic mean concentration of 3,827.8 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 15 out of 50 samples having higher levels than 3 logs cfu/g)

About | Technical issues | Introduction | 2-class enrichment | 2-class counts | 3-class counts | 3-class mixed | 2-class enrich sensspec | TableSensSpec

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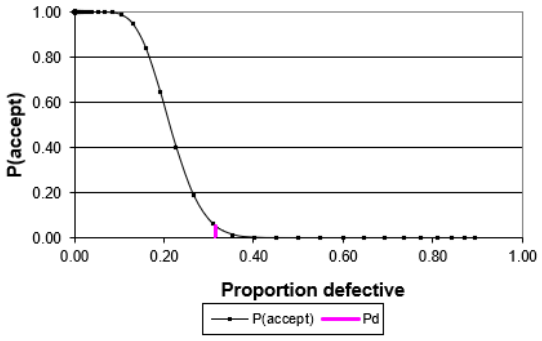
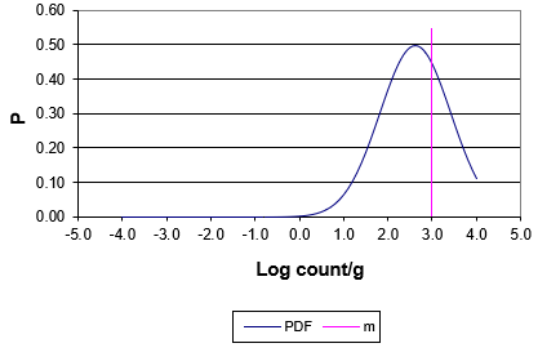
This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 702 cfu/g and an arithmetic mean concentration of 3828 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 15 out of 50 samples having higher levels than 3 logs cfu/g)

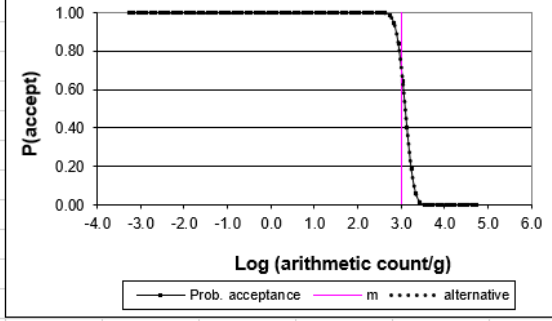
Operating characteristic curve for proportion defective, with n=50 and c=10



Probability density function (PDF) for log counts. Distribution mean = 2.62 and sigma = 0.80



Operating characteristic curve scaled to relate log arithmetic mean count to m



Lot acceptance for Pd			P(accept)	
Pd	10	%	99.1	%
actualPd	31.6	%	5.00	%

INPUTS	
mean	2.62
sigma	0.80
m	3
n	50
c	10

P(accept)		
Computed	5.00	%
Desired	5	%

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject)	95.00	%

ALTERNATIVE n AND c		P(accept)	
mean	2.62	Computed	5.00 %
sigma	0.80	Target, left	5.00 %
m	3		
n	50		
c	10		

For any value of n and c imputed find the m that gives the same P(accept) as the model on the

Sandbox: for your own calculations			
FSO	3		
complient	0.684404	not comply	0.315596
%	68.44038	%	31.55962

Means			
Arithmetic (=Average)		Geometric (=Median)	
2253.1	cfu/g	413.0	cfu/g
3.35	log cfu/g	2.62	log cfu/g

Implied Acceptance level		
Percentile	z-score	Concentration at this percentile
99.9	3.10	5.09
FSO	P(exceedance)	target level
5.09	0.000973	2.615961

This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 413.0 cfu/g and an arithmetic mean concentration of 2,253.1 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 10 out of 50 samples having higher levels than 3 logs cfu/g)

About | Technical issues | Introduction | 2-class enrichment | 2-class counts | 3-class counts | 3-class mixed | 2-class enrich sensspec | TableSensSpec

Accessibility: Investigate

This sampling plan would provide 95 % confidence that a lot of food containing a geometric mean concentration of 413 cfu/g and an arithmetic mean concentration of 2253 cfu/g (and having a standard deviation of 0.80 log cfu/g), would be rejected (i.e. more than 10 out of 50 samples having higher levels than 3 logs cfu/g)

Performance of the sampling plans

c-value	σ	log geometric	Log arithmetic	Geometric (cfu/g)	Arithmetic (cfu/g)
20	0.8	3.1	3.8	1128	6155
15	0.8	2.9	3.6	706	3828
10	0.8	2.6	3.4	413	2253
20	1.2	3.1	4.7	1198	54,510
15	1.2	2.8	4.4	588	26,734
10	1.2	2.4	4.1	266	12,073

So over the years we get about a 0.5 log improvement, factor 3 in level

A look from the actual situation in a country / slaughterhouse

European Food Safety Authority

EFSA Journal 2010; 8(03):1503

SCIENTIFIC REPORT OF EFSA

Analysis of the baseline survey on the prevalence of *Campylobacter* in broiler batches and of *Campylobacter* and *Salmonella* on broiler carcasses in the EU, 2008[1]

Part A: *Campylobacter* and *Salmonella* prevalence estimates

European Food Safety Authority[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

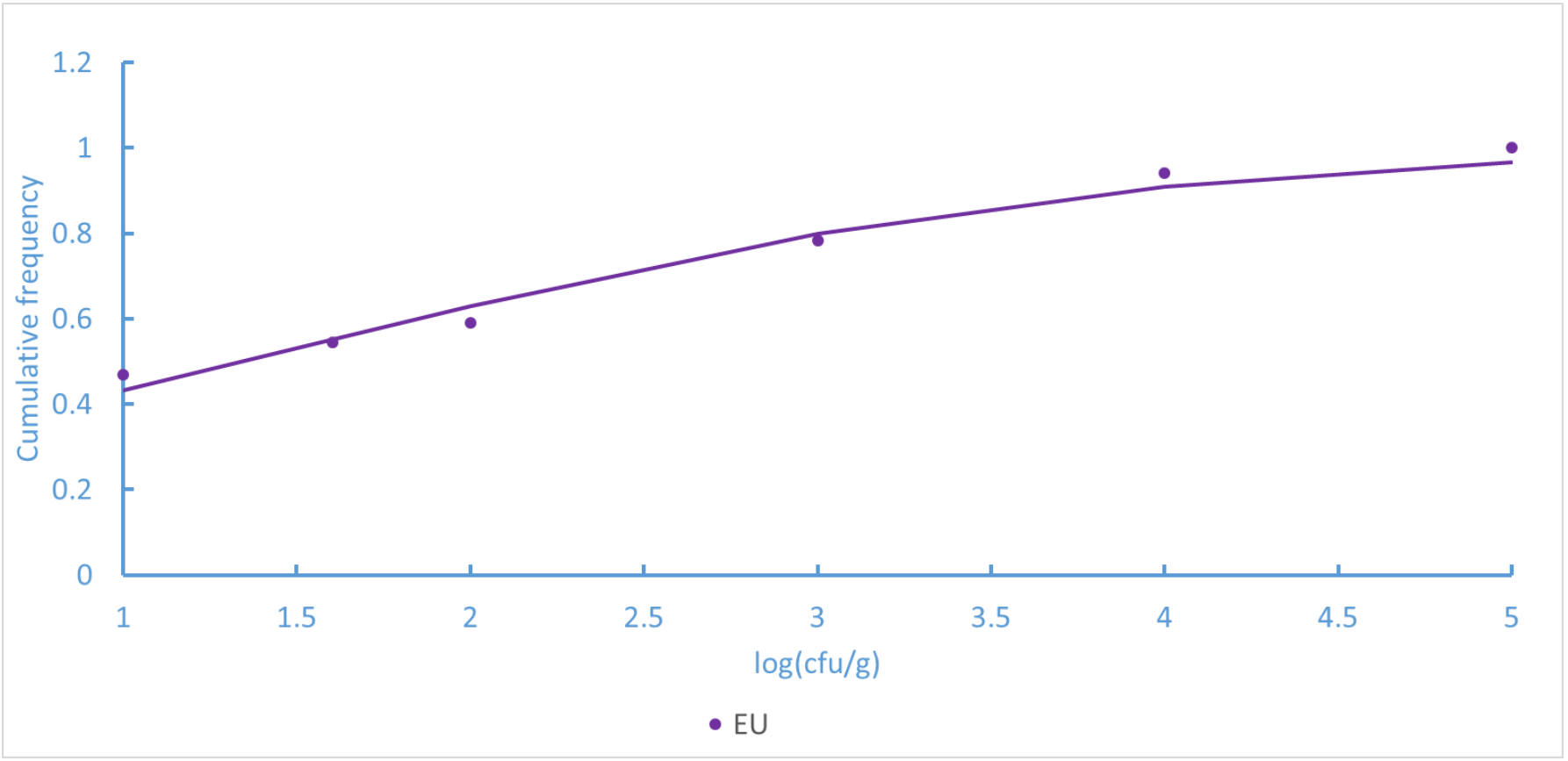
This scientific output, published 16 September 2011, replaces the earlier version published on 7 March 2011[4].

Table 5. **Categorised *Campylobacter* counts present on broiler carcasses, in the EU*, 2008**

Country	*Campylobacter* enumeration						Total
	<10 cfu/g	10-39 cfu/g	40-99 cfu/g	100-999 cfu/g	1,000-10,000 cfu/g	>10,000 cfu/g	
Austria	146	37	45	86	63	31	408
	35.8	*9.1*	*11.0*	*21.1*	*15.4*	*7.6*	*100*
Belgium	188	20	19	74	66	13	380
	49.5	*5.3*	*5.0*	*19.5*	*17.4*	*3.4*	*100*
Bulgaria	163	1	15	52	28	21	280
	58.2	*0.4*	*5.4*	*18.6*	*10.0*	*7.5*	*100*
Cyprus	352	0	1	2	2	0	357
	98.6	*0*	*0.3*	*0.6*	*0.6*	*0*	*100*
Czech Republic	205	4	8	92	78	35	422
	48.6	*1.0*	*1.9*	*21.8*	*18.5*	*8.3*	*100*
Denmark	302	10	11	38	29	6	396
	76.3	*2.5*	*2.8*	*9.6*	*7.3*	*1.5*	*100*
Estonia	100	0	1	0	1	0	102
	98.0	*0*	*1.0*	*0*	*1.0*	*0*	*100*
Finland	361	4	2	1	1	0	369
	97.8	*1.1*	*0.5*	*0.3*	*0.3*	*0*	*100*
France	102	54	47	154	54	11	422
	24.2	*12.8*	*11.1*	*36.5*	*12.8*	*2.6*	*100*

cfu/g	<10	10-39	40-99	100-999	1000-10000	>10000	Total
EU	4320	685	436	1772	1453	534	9200

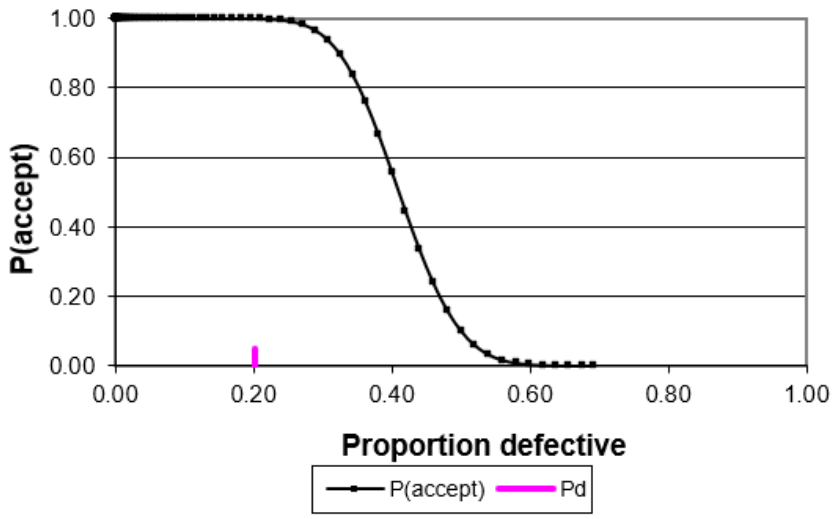
Frequency distribution



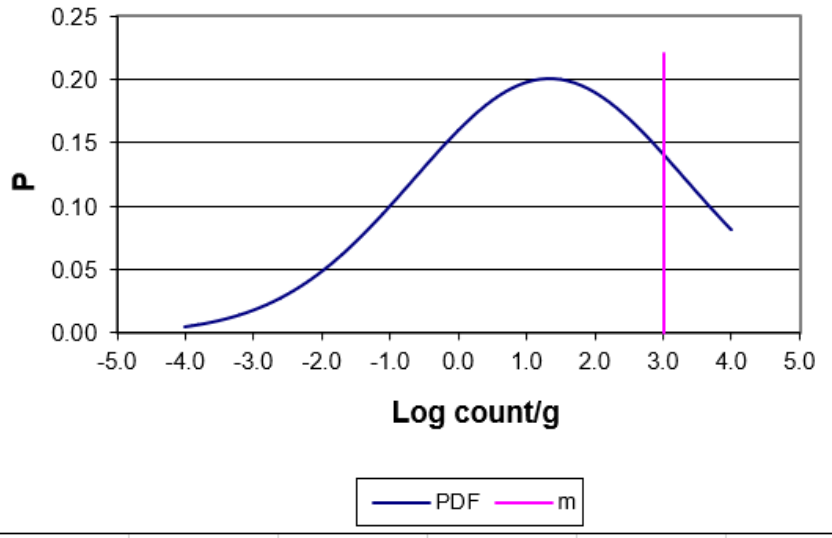
	mean	σ
EU	1.339	1.984

c=20, P_{reject}=0.04%

Operating characteristic curve for proportion defective, with n=50 and c=20



Probability density function (PDF) for log counts. Distribution mean = 1.34 and sigma = 1.98



Lot acceptance for Pd			P(accept)	
Pd	10	%	100.0	%
actualPd	20.1	%	99.96	%

INPUTS	
mean	1.34
sigma	1.98
m	3
n	50
c	20

P(accept)		
Computed	99.96	%
Desired	5	%

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject)	0.04	%

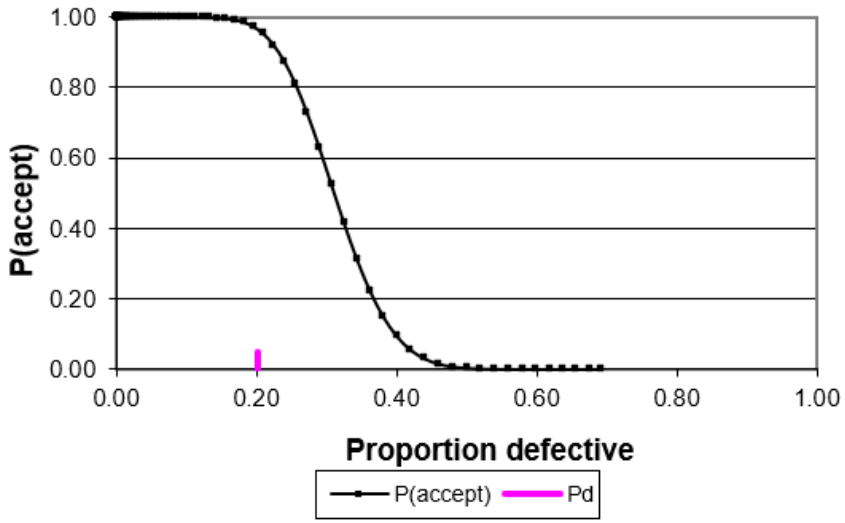
Sandbox: for your own calculations

FSO	3		
complient	0.798759	not comply	0.201241
%	79.87592	%	20.12408

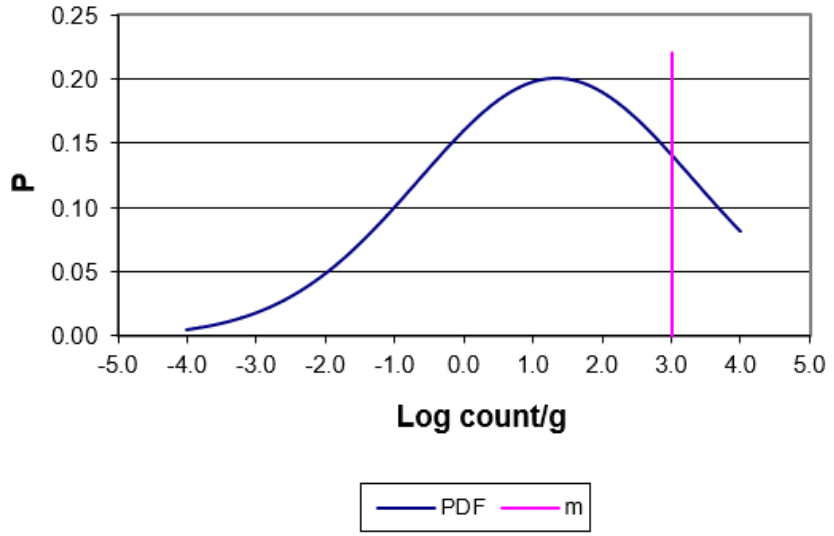
Means

c=15, P_{reject}=3.3%

Operating characteristic curve for proportion defective, with n=50 and c=15



Probability density function (PDF) for log counts. Distribution mean = 1.34 and sigma = 1.98



Lot acceptance for Pd			P(accept)	
Pd	10	%	100.0	%
actualPd	20.1	%	96.75	%

INPUTS	
mean	1.34
sigma	1.98
m	3
n	50
c	15

P(accept)		
Computed	96.75	%
Desired	5	%

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject)	3.25	%

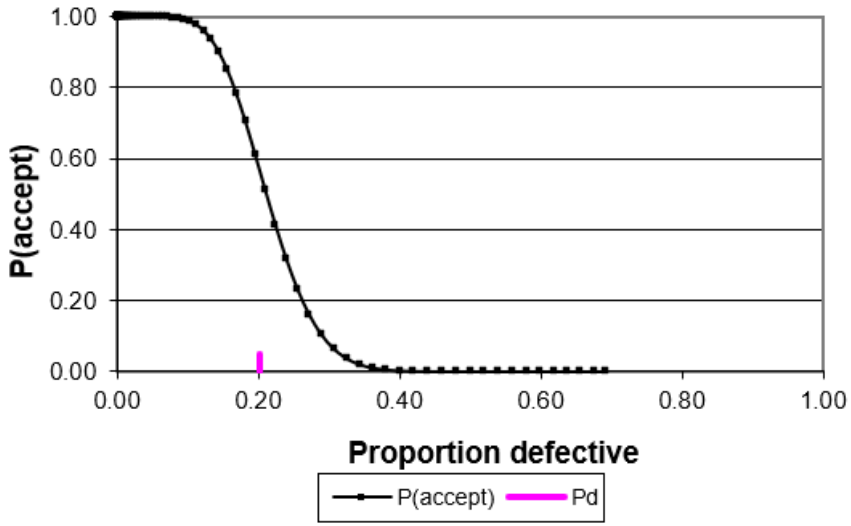
Sandbox: for your own calculations

FSO	3		
complient	0.798759	not comply	0.201241
%	79.87592	%	20.12408

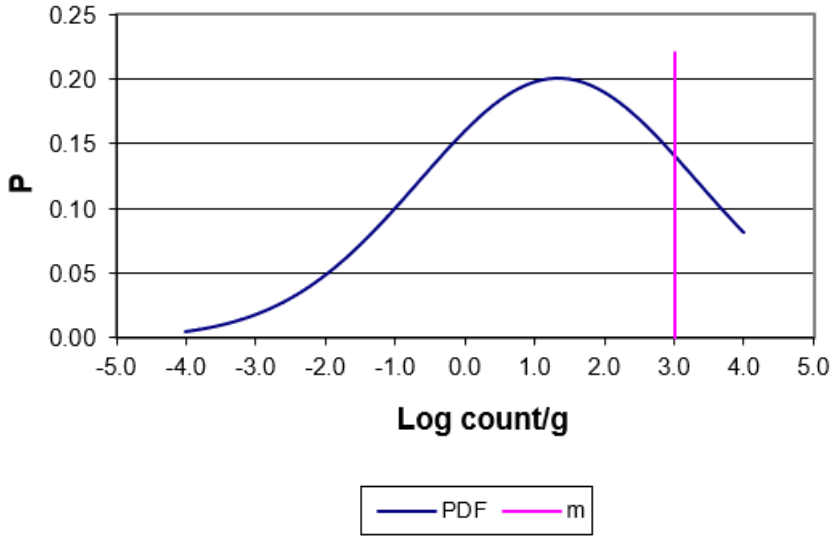
Means

$c=10$, $P_{reject}=43\%$

Operating characteristic curve for proportion defective, with n=50 and c=10



Probability density function (PDF) for log counts. Distribution mean = 1.34 and sigma = 1.98



Lot acceptance for Pd			P(accept)	
Pd	10	%	99.1	%
actualPd	20.1	%	57.49	%

INPUTS	
mean	1.34
sigma	1.98
m	3
n	50
c	10

P(accept)		
Computed	57.49	%
Desired	5	%

Find mean that gives desired P(accept)

Find n that gives desired P(accept) or better (less)

P(reject)	42.51	%

Sandbox: for your own calculations			
FSO	3		
complient	0.798759	not comply	0.201241
%	79.87592	%	20.12408

Means

Results ICMSF sheet

	mean log	σ	*P* (>1000)	*c*=20	*c*=15	*c*=10
EU	1.3	2.0	0.20	0.00035	0.033	0.43

Conclusions

The ICMSF tool can illustrate and calculate all kinds of effects of factors both graphically as well as numerically