

Derivation of Ratios for Female Urinals

RM Harris

Derivation of Ratios

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2. Revision History

Issue	Date	Page	Remarks
0.01	29 th August 2011	All	Formalisation of loose V5 paper, dated 24/08/11 under doc control
0.02	2 nd September 2011	4,5,6	minor clarification of formulations

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3. Purpose

This document was written at the behest of Jonathan Reid, Portakabin, to underpin recommendations of female urinals to be considered for editing Portakabin's draft Sanitation Chapter, being submitted to the HSE for the Revised Purple Guide. It sets forth the view and aims of *Sanitation Choice* interest group.

4. Disclaimer

No liability shall be accepted for any statement, implied or explicit, or any inference, or promise of results.

5. Definitions

a.k.a.	also known as
EIF	Event Industry Forum
FUD	Female Urination Device
HSE	Health and Safety Executive
lhs	left-hand side
N/A	not applicable
rhs	right-hand side
STO	Specific Time Occupancy
TBA	to be advised
TBC	to be confirmed
TBD	to be determined
WC	water closet
wrt	with respect to

6. Related Documents

- Ref A HSG195 Guide to Safety at Musical and other Events, HSE
- Ref B BS 6465
- Ref C Suggested rewrite of Chapter 14 submitted to the EIF in 2010
- Ref D Version of Chapters 12 and 13 produced by Portakabin June 2011

7. Summary

This recommendation is based on a statistical model that is consistent with existing and proposed new guidance for toilet ratios at outdoor public events. It captures and establishes a trend towards wider adoption of female (stand-up) urinals. It is timely for the Revision of HSG195 – the Purple Guide.

8. Methodolgy

BS6465 and the current hsg195 indicate minimal provision of toilets (which may be temporary and portable WC units) for male and female patrons respectively, and also urinals for males (only). Not having to hand independent biological and social statistics, we have assumed that relevant human data played their part in the formulation of both BS6465 and later provisions of "minimal" toilet ratios.

Derivation of Ratios

A simple mathematic model is proposed here to derive the separate demands from males and females for various "toilet" functions. That model is then scaled with input data that reproduce the numbers of WC units and urinals specified in the existing 'standards'. On that basis rests the accuracy of the model and the human data used in it. The newfound advantage is the ability of the model to predict the need for separate urinals for female use.

It is noted that each of the legacy numbers or ratios is explicitly a "minimum" and not necessarily the ideal for any particular event. The extra recommendation arising from this analysis is similarly a "minimum". All the recommendations are equally capable of being scaled up by a simple factor as required.

The present model comprises a set of mathematical "baseline equations" and some algebraic manipulations. The "baseline equation" expresses the fact that, for a steady state, wherein queues neither grow nor shrink, demand and capacity must balance exactly. With that balance assumed, the formalised human demand can be calculated from the capacity of the specified deployment of toilet equipment.

Human data:

α = hourly rate of visiting urinal for males, per male person

β = hourly rate of visiting WC for non-urinating bodily function, per person (males or female)

γ = hourly rate of visiting WC or female urinal for urine only, per female person

a = statistical average cycle time for male urinal (hour units)

b = statistical average cycle time for non-urinating bodily function (males or female) (hour units)

g = statistical average cycle time for female urinating in WC (hour units)

It is convenient to define a "Specific Time Occupancy" (STO) as the average time spent on a function, per person, per elapsed hour of the day. Therefore the STO for male urinating = $\alpha.a$
Similarly, the STO for other non-urinating bodily function = $\beta.b$ (male and female)
and for female urinating, the STO = $\gamma.g$

Given a definition of human demand, the model can then reverse the analysis to predict minimal provision of new types of toilet. Some more input variables are then needed, See Para 3.2:

- p = speed-up factor for stand-up urinal relative to portable cabin-style WC.
- q (%) is percentage adoption by females of female urinal at a particular type of event.

Both p and q are subject to debate and are not static. They vary over time, and so are treated as *parameters* of the model. It is almost assured that q should go on increasing as both the sales of a whole range of female urination devices (FUD) continue to flourish, and the public awareness of female urinals grows.

9. Use of Model to Decompose BS6465

9.1. Male demand for urinals

In the elapsed time of one hour, male urinals are visited $N.\alpha$ times, where N males are in the area.

The aggregate time usage is then $N.\alpha.a$ hours, i.e. N times the STO

If $N.\alpha.a < 1$ then one urinal is sufficient.

If $N.\alpha.a > 1$ then more than one urinal is required. In general, the number urinals required to satisfy the demand precisely, $U = N.\alpha.a$

BS6465 indicates that if $N = 150$, $U = 1$, therefore the baseline equation becomes:

$$1 = 150.\alpha.a \quad \text{therefore} \quad \alpha.a = 1/150 \text{ (hours)} = 0.4 \text{ minute per male per hour}$$

10. Use of Model to Predict Demand for Female Urinals

10.1. Proportion by occupancy

Following the previous logic, we assert that the number WC units that are effectively taken up with urinating,

$$\begin{aligned} W_{F-U} &= N \cdot \gamma \cdot g && \text{when there are } N \text{ females in the area.} \\ &= N \cdot (0.00770238) \end{aligned}$$

Those (W_{F-U}) toilets represent a general proportion, R , of total number of WC units allocated to females, where

$$R = (W_{F-U}) / (W_F) \quad \text{since (BS6465) } W_F = N/100,$$

$$R = . \gamma \cdot g \times 100 = 0.00770238 \times 100 = 0.770238$$

That means that 77% of the WC occupation is for urinating only, based on input data from BS6465.

10.2. Two Key Parameters

Any recommendation of the number of dedicated female urinals has to take account of the two model *parameters* p and q .

p – is the cycle-time efficiency defined as the cycle time for urinating in a cabin-style portable WC divided by the corresponding cycle time in a dedicated (female) urinal.

q (%) – percentage of females who will happily transfer from a WC to a berth at a female urinal.

Standing to urinate saves on time wasted in cabin-style portable WC, since hand washing, etc. can be done in the common space of a urinal block, much as it can in trailer toilets. With certain types of FUD the necessity to remove clothing is mitigated, saving yet more time. Estimates of the speed factor vary up to 2:1 but we here will take a conservative figure of 1.5 for parameter p .

Until this Revision of the Guide, the *status quo* is has been WC only for females. The introduction of female urinals is, as with all *new technology* best done slowly. The Guide is concerned only with setting the minimum for each category of toilet provision and certainly does not set out to inhibit more adventurous toilet provision. Therefore, this recommendation for the *new technology* is tempered with conservative estimates of its acceptance by the general event-going public. That conservatism is especially applicable to the pitching of parameter q (%).

It is known from experience gained over a wide-range of outdoor events, ranging from mass runs/walks, over sedate musical concerts, to 4 day-festivals, that q can vary widely. A well-known musical festival has furnished female urinals amply enough for a $q=30\%$ uptake. Our own experience of intermediate events suggests a lower figure of 8%. In order to anticipate part of the year-by-year growth in popularity, let us set $q = 10\%$.

10.3. Application of Parameters

In situations where female urinals are appropriate, taking $q = 10\%$ determines an upper limit on the number of WC toilets that may be replaced by female urinals. Hence, of the 77% of WC cabins that could be dedicated to urinating, only 10% may be replaced with dedicated female urinals. Therefore, removing 10% of the 77% leads to a reduction in the (BS6465) WC count from

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$$W_F \text{ to } (1 - 0.77/10) W_F = 0.923 W_F$$

That diminution is then compensated by providing S berths at a female urinal, where $S = (0.077 \times W_F) / p = 0.05133 \times W_F$ or

1 female urinal berth per 1948 females.

11. Comparison with Portakabin's Upgraded Toilet Ratios

The Specific Time Occupancy (STO) results are tabulated below for input data based BS6465.

Function		Specific Time Occupancy				
		variable	hour per hour	minutes per hour	min. per 6 hr period	
male	urinating	$\alpha.a$	1/150	0.4	2.4	
	toilet (WC)	$\beta.b$	1/500	0.12	0.72	
female	sanitary	T	0.00029762	0.0178	0.6 0.107	
	toilet	$\beta.b$	1/500	0.12		0.72
	urinating	$\gamma.g$	0.00770238	0.46		2.76
			= 76% of total female WC occupancy			
W_F		0.01	= 1 per 100 females			
female/male urinating		115%				

Table 1 Based on input data from BS6465 toilet ratios

Table 2 shows the results of a similar set of calculations performed on the Portakabin ratios for events with gate opening time of 6 hours or more with alcohol and food served in quantity.

Function		Specific Time Occupancy				
		variable	hour per hour	minutes per hour	min. per 6 hr period	
male	urinating	$\alpha.a$	1/100	0.6	3.6	
	toilet (WC)	$\beta.b$	1/400	0.15	0.9	
female	sanitary	T	0.00029762	0.0178	0.8 0.107	
	toilet	$\beta.b$	1/400	0.15		0.72
	urinating	$\gamma.g$	0.0108333	0.632		3.8
			= 79% of total female WC occupancy			
W_F		0.1333	= 1 per 75 females			
female/male urinating		105%				

Table 2 Based on input data from Portakabin's Panel 3

Hence, supplanting the BS6465 input data with those from Portakabin, we arrive a new figure of 79% of WC cabins that could be dedicated to urinating. Again, if only $q = 10\%$ may be replaced with dedicated female urinals, the number of WC can be reduced to $(1 - 0.79/10) W_F = 0.921 W_F$. That diminution is then made up by providing a number, S , of berths at a female urinal, where $S = (0.079 \times W_F) / p = 0.0527 \times W_F$ or

1 female urinal berth per 1424 females.

12. Worked example using Portakabin ratios

An outdoor event with over 6 hours and alcohol, etc. has 20,000 attending the main area with equal numbers of males and females. Total number of WC for females, $W_F = 133.33$

Of those, 79% of their capacity is used only for urinating, equivalent to 105.33 WC units.

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With parameter $q = 10\%$, 90% of females will prefer to use the WC for urinating, so we reserve 90% times $105.33 = 94.8$ WC for them to use, and release 10.5 WC to be replaced with an equivalent capacity at a block of female urinals. The total number of WC for females is then precisely:

$$133.33 - 10.5 = 122.8, \text{ or } 1 \text{ WC per } 81.4 \text{ females}$$

Rounding that figure leads to the recommendation:

One (WC) toilet per 81 females

The lost toilet capacity is made up at the female urinal with a smaller number of berths. Since the female urinal is deemed to be $p = 1.5$ times as efficient, we need only $10.5/1.5 = 7$ female urinal berths (precisely) to complete the total sanitary facility.

That amounts to a ratio of 1 berth at a female urinal per 1428 females. Rounding up, the recommendation is to provide:

One female urinal (berth) per 1430 females
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Generalising that result, a new Panel could be added, for the same conditions as Panel 3 but when the suitability for female urinals has been established for a particular event.

For events with a gate opening time of 6 hours or more with alcohol and food served in quantity, when female urinals are deemed appropriate	
<i>Female</i>	<i>Male</i>
1 toilet per 81 females	1 toilet per 400 males
plus 1 female urinal per 1430 females	plus 1 urinal per 100 males

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APPENDIX A:

On average a female in the EEA uses about 12 sanitary devices per (28-day) month, occupying about 1 minute for each action. That leads to a statistical rate of WC occupancy (STO) of

$12/28 = 3/7$ minutes per female, per day, or

$T = 0.00029762$ hour per female per elapsed hour

$= 0.017856$ minutes per female per elapsed hour.