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Standards Development and Support Technical Report

Motorcycle Useful Life

by

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Abstract

A useful life mileage for motorcycles has been determined using Gallup motorcycle owner survey data and registration information. The useful life mileage is 12000 km for motorcycles with engine displacements between 49 and 170 cubic centimeters, and 30000 km for motorcycles with displacements of 170 cubic centimeter or greater.

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Introduction

To determine the durability test requirements for motorcycles, it is necessary to know their useful life mileage. While the Clean Air Act defines the useful life of motor vehicles to be 5 years or 50,000 miles, which ever is greater, it is the opinion of the Office of General Councel that "The Statutory Definition of Useful Life as 50,000 miles would not apply to motorcycles" (Ref. 6).

The following analysis defines useful life as the mean (average) mileage a motorcycle can be expected to accumulate during its lifetime. The discussion presents the analysis technique, the detailed calculations, and a description of the data and associated assumptions.

Discussion

Definition of Useful Life Mileage

The useful life mileage of a motorcycle is defined as the mean (average) mileage a motorcycle can expect to accumulate over its lifetime, and is given by equation 1,

$$\int_0^\infty MR(t) * Pr(t)\, dt = \text{useful life mileage} \qquad 1)$$

where:

MR = yearly distance traveled at a given age t

Pr = probability of survival at a given age t

Equation 1 can be approximated by the following summation over discrete intervals.

$$\sum_{i=1}^{\infty} MR_i * Pr_i \approx \text{useful life mileage} \qquad 2)$$

Examining equation 2 reveals that the largest contribution to the useful life mileage occurs for the newer motorcycles whose probability of survival, Pr, is high. This is a desirable feature of the equation because more data is available for the newer motorcycles and fewer assumptions in processing these data are required.

The term MR_i, the distance traveled in year i, is evaluated using Gallup survey data of motorcycle accumulated mileage and age. The desired quantity is the average number of miles accumulated in a year by motorcycles of age i. This can be evaluated from equation 3,

$$MR_i = AM_i - \sum_{j=1}^{i-1} MR_j$$

$$= AM_i - AM_{i-1} \qquad 3)$$

where:

AM_i = total accumulated mileage for a motorcycle of age i

Note that MR_i is not the accumulated mileage divided by the age. This would give the average miles per year traveled over the age interval, and not the miles per year traveled in year i.

The term Pr_i, the probability of survival, is evaluated using registration data and the survey results. Pr_i is defined as the number of motorcycles of age i in operation today divided by the number originally sold new. The number of motorcycles of age i still operating can be estimated from the Gallup survey results. The number originally sold new is obtained from registration data.

The Gallup Data

The Motorcycle Industry Council (MIC) commissioned the Gallup Organization to perform a survey of motorcycle owners. The Gallup Organization surveyed 4187 motorcycle owners nationally who owned a total of 4800 motorcycles. Mini cycles were excluded from the survey. The data were weighted according to the distribution of motorcycle ownership in the country, giving 9888 weighted responses. The EPA received a tape of the survey data, from which the data in this report were obtained.

The survey asked motorcycle owners to go look at their odometers and report the mileage. If the owner refused, or there was no odometer or it was not working, a mileage estimate was obtained. The accumulated mileage data were analyzed and it was determined that those people who estimated mileage and had no odometer or working odometer on the average estimated accumulated mileage higher than the rest of the owners. Therefore this group was eliminated from the data base. All motorcycles used only for off road riding were also excluded because this type of motorcycle is not covered by the emission regulations. A final exclusion was the 1974 model year motorcycles. It was felt that the mileage accumulation rate of new motorcycles would be high, and thus projecting a yearly mileage based upon less than one years usage was not valid. The data supported this conclusion. Thus the data base was reduced to street and dual purpose motorcycles of 1973 and older model year with working odometers.

Using this data base the following information relating to useful life mileage was determined: Accumulated mileage versus age (AM_i), yearly mileage (MR_i) versus age, and the number of motorcycles still in existence versus age (numerator of Pr_i).

Registration Data

The remaining term to be evaluated in the useful life equation is the number of new motorcycles sold each year (denominator of Pr_i). The required data were obtained from new (first time) motorcycle registrations. In general the data set of street and dual purpose motorcycles selected from the Gallup data is the set of registerable motorcycles. Thus the two data sources have a consistent base and can be used together to calculate Pr_i.

New motorcycle registration data are available only back to 1967, requiring estimates to be made for the older model year motorcycles. Fortunately motorcycles older than 1967 contribute less than 20 percent of the useful life mileage, and therefore errors made in estimating new registrations are minimized. The procedure used to estimate new motorcycle registrations is presented in Appendix I.

Table I presents the new motorcycle registration data versus model year, the number of motorcycles of a given model year still operating, and the calculated value of Pr_i.

TABLE I

ALL ENGINE SIZES $\geq$ 50cc

Model Year	Age, Years	1st time registrations, $N_i * 10^3$	# still operating $R_i * 10^3$	Probability of Survival, Pr_i
1973	1	1190	1153	.97
72	2	1006	1029	1.02
71	3	928	755	.81
70	4	751	499	.66
69	5	550	311	.57
68	6	437	236	.54
67	7	287	175	.61
66	8	587	150	.26
65	9	545	118	.22
64	10	317	46	.15
63	11	225	31	.14
62	12	153	16	.10
61	13	107	10	.09
60	14	106	6	.06
		Ref. 1	Ref. 2 (Also see Appendix II)	$Pr_i = N_i/R_i$

In Table I the motorcycle age is also presented. The Gallup survey was taken in the last half of May 1974. Since this is approximately the time at which them median sale of a given model year motorcycle occurs, the average age of a motorcycle will be equal to the model year subtracted from 1974.

Splitting the Data into Displacement Categories

The proposed regulations divide motorcycles into two engine displacement categories, those between 49 and 170 cubic centimeters and those greater than or equal to 170 cc, i.e. 'small' and 'large' motorcycles. An examination of accumulated mileage versus engine displacement category indicated small motorcycles have a significantly shorter useful life mileage than large motorcycles, and thus a displacement category dependent useful life mileage was required. A single non-displacement related useful life mileage would have unfairly penalized small motorcycles.

The Gallup data were easily split into displacement categories since engine size was a question asked in the survey. The 1974 to 1967 new registration data also contained displacement information. The older registration data contained no displacement data, requiring an estimate of the displacement distribution. The estimate was made by extrapolating the trend towards purchasing larger motorcycles and from motorcycle import data. Again the older motorcycles contribute a small percent of the useful life mileage, and thus the effect of an estimate error is small.

Table II presents the registration data for each displacement category. N_i is the number of new first time registrations, which approximates the number of new registerable motorcycles sold.

TABLE II

SPITTING DATA INTO DISPLACEMENT CATEGORIES

Model Year	$N_i * 10^3$	Fraction $\geq$ 170 cc	$N_i * 10^3$ $50 \leq cc < 170$	$N_i * 10^3$ $cc \geq 170$
1973	1190	.73	321	869
72	1006	.71	292	714
71	928	.66	316	612
70	751	.54	346	406
69	550	.51	270	280
68	437	.51	214	223
67	287	.48	149	138
66	587	.42	340	247
65	545	.38	338	207
64	317	.33	212	105
63	225	.30	158	68
62	153	.30	107	46
61	107	.30	75	32
60	106	.30	74	32
59	102	.30	71	31

Table III shows the calculations to determine the probability of survival, Pr_i, for each displacement category. R_i is determined from the Gallup survey data. (See Appendix II)

TABLE III
PROBABILITY OF SURVIVAL

Model Year	50 ≤ cc < 170			cc ≥ 170		
	Ni	Ri	Pri	Ni	Ri	Pri
1973	321	345	1.07	869	809	.93
72	292	296	1.01	714	734	1.03
71	316	233	.74	612	522	.85
70	346	216	.62	406	283	.70
69	270	125	.46	280	186	.66
68	214	88	.41	223	148	.66
67	149	79	.53	138	96	.70
66	340	69	.20	247	81	.33
65	338	66	.20	207	52	.25
64	212	25	.12	105	20	.13
63	158	8	.05	68	22	.32
62	107	2	.02	46	14	.30
61	75	2	.03	32	8	.25
60	74	2	.03	32	4	.12
59	71	1	.01	31	1	.03

N_i = number of new registerable motorcycles, Ref. 1

R_i = number of registerable motorcycles still operating, Ref. 2

$Pr_i = R_i/N_i$ = probability of survival

cc = cubic centimeter engine displacement

Yearly Mileage Rate

As described by Equation 3, the miles traveled per year is calculated using total accumulated mileage, which was obtained from the Gallup survey data. Because there are only a few sample responses for the older motorcycles, the mean accumulated mileage for old motorcycles tends to show large variations from model year to model year. To overcome this difficulty, a least squares second order polynomial was fit through all the data points, and accumulated mileage was calculated from the fit equation. Figure 1 shows the average accumulated mileage versus model year and the best fit equation which has the form:

$$\text{Accum. miles} = a_o + a_1 * \text{year} + a_2 * \text{year}^2$$

Calculation of the Useful Life Mileage

Equation 2 is now used to calculate the useful life mileage. The annual mileage rate is obtained from equation 3 and the curve fit accumulated mileage of Figure 1. The probability of survival is obtained from Table III. The calculations, presented in Tables IV and V, result in useful life mileages of 10633 km for motorcycles between 49 and 170 cc, and 28232 km for motorcycles greater than or equal to 170 cc.

Recommended Useful Life Mileage for Use in the NPRM

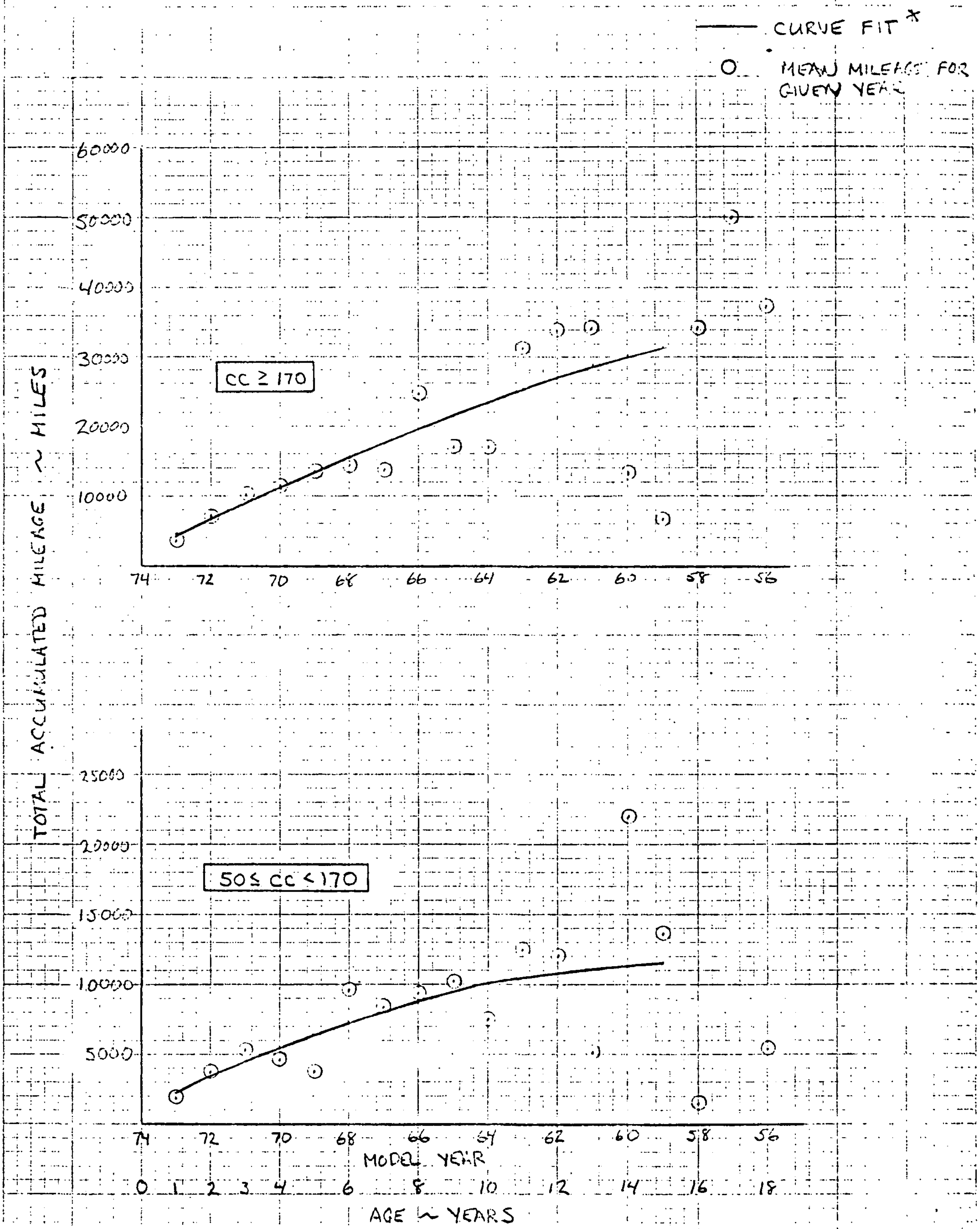
For the actual specification of useful life mileage in the motorcycle regulations, it is considered appropriate to round up the calculated values. The rounded values result in even increments for durability testing and maintenance intervals. The relatively short distances required do not put an unreasonable burden upon the manufacturers. It is also felt that once manufacturers are required to demonstrate motorcycle durability, the designs tend to improve, and the useful life mileage will increase beyond the levels upon which these calculations were based.

The recommended useful life mileages are:

	Calculated Values	Recommended for Regulations
$50 \leq cc < 170$	10633 km	12000 km
$cc \geq 170$	28232 km	30000 km

FIGURE 1

ACCUMULATED MILEAGE VS AGE



* THE CURVE FIT IS THROUGH ALL DATA POINTS, NOT THE MEANS SHOWN HERE

Table IV

Useful Life Mileage - $50 \leq cc < 170$

Model Year	Age	AM_i	MR_i	Pr_i	$MR_i * Pr_i$
1973	1	2160	2160	1.07	2311
72	2	3369	1209	1.01	1221
71	3	4495	1126	.74	833
70	4	5537	1042	.62	646
69	5	6495	958	.46	441
68	6	7370	875	.41	359
67	7	8161	791	.53	419
66	8	8869	708	.20	142
65	9	9493	624	.20	125
64	10	10034	541	.12	65
63	11	10490	456	.05	23
62	12	10864	374	.02	8
61	13	11153	289	.03	9
60	14	11359	206	.03	6
59	15	11482	123	.01	1
					Σ = 6608 miles =10633 km

AM_i = accumulated miles calculated from Figure 1, miles

MR_i = yearly mileage rate from equation 3, miles per year i

Pr_i = probability of survival from Table III

Table V

Useful Life Mileage - cc ≥ 170

Model Year	Age	AM_i	MR_i	Pr_i	$MR_i * Pr_i$
1973	1	4342	4342	.93	4038
72	2	6767	2425	1.03	2498
71	3	9121	2354	.85	2001
70	4	11402	2281	.70	1597
69	5	13611	2209	.66	1458
68	6	15748	2137	.66	1410
67	7	17813	2065	.70	1446
66	8	19807	1994	.33	658
65	9	21728	1921	.25	480
64	10	23577	1849	.13	240
63	11	25354	1777	.32	569
62	12	27059	1705	.30	512
61	13	28692	1633	.25	408
60	14	30252	1560	.12	187
59	15	31741	1489	.03	45
					Σ =17546 miles
					=28232 km

Other Useful Life Mileage Estimates

The only other estimate of useful life mileage based on extensive survey or registration data was made by JAMA (Ref. 3) for motorcycle usage in Japan. The results of this survey are:

51 to 125 cc	15100 km
126 to 250 cc	21000 km
$\geq$251 cc	24200 km

The results, although higher for the small motorcycles and lower for the large motorcycles, compare favorably with the results obtained herein.

The motorcycle manufacturers, in their comments to the ANPRM, typically suggested 20000 km for large motorcycles and 10000 km for the smaller motorcycles. These values for useful life mileage were not supported by significant data.

Useful Life Age

The average useful age for a motorcycle can be calculated from the age and probability of survival data. The useful life age is given by equation 4.

$$\int_0^\infty Pr(t)dt \qquad 4)$$

or for one year intervals,

$$\sum_{i=1}^{\infty} Pr_i \qquad 5)$$

The useful life age is:

5.5 years	$50 \leq cc < 170$
7.3 years	$cc \geq 170$

References

1. Motorcycle Industry Council "facts and figures", titled:

"Distribution of Total New U.S. Motorcycle Registrations", (source: R.L. Polk & Co.).

2. Gallup Organization Inc., Survey of Motorcycle Owners, 1974, (Data processed by EPA from a tape of the survey results).

3. Japan Automobile Manufacturers Assoc. Inc., "A Survey Report on the Use of Motorcycles," December 1974.

4. R.L. Polk & Company, New Registration Data, 1967-1973.

5. Gallup Organization Inc., "Survey of Motorcycle Ownership, Usage, and Maintenance", conducted for MIC, January 1975, pg 4.

6. "Ramification of Current Definition of Motorcycles and Determination of Useful Life for Motorcycles", William F. Pederson, Attorney OGC to Rodney W. Jenkins, Staff Assistant MSAPC, June 20, 1974.

Appendix I

To determine the probability of survival, Pr_i, the number of new registerable motorcycles sold per year needs to be known. These data are available only back to 1967. Therefore for years prior to 1967, an estimate based on other available data was made. The available data are:

New first time registrations 1967-1973

Total U.S. registrations 1960-1973 plus 1953

The approach is to calculate, using the above data for 1967 to 1973, the percent of the registered population which fails to register the following year. This is defined as the retirement rate of the population. The mean for 1967 to 1973 is calculated and used as an assumed retirement rate for 1966 to 1958. Thus the number of new registerable motorcycles for these years can be back calculated.

The calculations are shown in the following table. The subscript refers to the year. Those values below the solid line are from calculations containing assumed data.

D_j, the number of previously registered motorcycles not registered the next year is assumed to be the number of motorcycles retiring in year j. D_j is calculated from year j + 1 data since if a registered motorcycle retires in year j it will not be reflected until year j + 1 registration data. I_j, the increase in total registrations per year, contains all new first time registered motorcycles minus those that retired. Thus for the years in which new registration data, N_j, is available, the retirement rate, $\%D_j$, can be calculated.

The calculation procedure is as follows:

For 1967 to 1973 data -

$I_j = T_j - T_{j-1}$ increase in total registrations

$D_j = N_{j+1} - I_{j+1}$ # retiring; N_{j+1} known

$\%D_j = D_j/T_j$

For 1958 to 1966 data, back calculate assuming $\%D_j = .15$ is a constant

$\%D_j = .15$ retirement rate assumed constant

$D_j = .15 * T_j$ # retiring

$N_{j+1} = D_j + I_{j+1}$ # new first time registrations

N_j is then used as the number of new registerable motorcycles sold for years 1966 to 1958.

Table A-1

Motorcycle Registration Data - All cc's

Year	$T_j * 10^3$	$N_j * 10^3$	$I_j * 10^3$	$D_j * 10^3$	% D_j	
1973	4353	1190	551			
72	3802	1006	457	639	17	Mean = 15
71	3345	928	530	549	16	
70	2815	751	499	398	14	
69	2316	550	215	252	11	
68	2101	437	148	335	16	
67	1953	287	200	289	15	
66	1753	587	371	87	5	
65	1382	545	397	207	15	
64	985	317	199	148	15	
63	786	225	126	118	15	
62	660	153	64	99	15	
61	596	107	21	89	15	
60	575	106	23	86	15	
59	552 (1)	102	23	83	15	
58	529 (1)			79	15	

T_j = total U.S. registrations as of end of year, ref. 1

N_j = number of new first time registrations, ref. 4

I_j = increase in total registrations = $T_j - T_{j-1}$

D_j = number of previously registered but not registered in year j: $D_j = N_{j+1} - I_{j+1}$

$\%D_j = D_j/T_j$

(1) estimate based on linear change between 1960 and 1953

Appendix II

The method of converting the Gallup survey data to estimates of national population is accomplished as follows.

Based on the estimated number of households in the U.S., the number of households owning motorcycles, and the number of motorcycles per household having a motorcycle, an estimate of the number of motorcycles in the U.S. is obtained. (Ref. 5) This includes all types of motorcycles except minicycles.

# of motorcycles in U.S. as of June 1974	7,064,000 ($\pm$ 312,000)
Weighted number of motorcycles in survey	9888
Conversion of weighted data to national estimate	= 7,064,000/9888 = 714.40

In the useful life calculations, the responses to those people not having a working odometer or no odometer were excluded. This involves about 8% of the registerable population and thus the conversion factor must be corrected. The conversion factor used in projecting a nation-wide estimate (R_i) from the Gallup data is:

$$\text{conversion factor} = 714.40 * 1.08$$

$$= \underline{771.6}$$

and,

$$R_i = (771.6) * (\text{weighted responses})$$