INJURED WORKER MORTALITY

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Abstract/Introduction

The paper discusses the NCCI Special Call for Injured Worker Mortality data and the ensuing analysis of that data. The design of the call and the company's ability to supply elements of the call is discussed.

The goal was to test the hypothesis that the mortality of pensioned workers differs significantly from that of the general population. Because of ambiguities in the data, the hypothesis cannot be accepted or rejected. It does appear that, at least for ages below 60, the reported injured worker mortality rate is higher than standard US Life. Between age 60 and 74, the injured worker mortality rate does not differ appreciably from U.S. Life.

The differences in mortality, even if accepted, do not imply significant redundancy or inadequacy of tabular reserves.

INJURED WORKER MORTALITY

Despite the existence of much supposition on the topic, the mortality of injured workers relative to the standard United States Life (USL) Tables has not been well analyzed. Interest waxes in time of deteriorating results, but then wanes as results improve. As if we need more proof that the 1980's represent a prolonged time of less than satisfactory compensation results, here is one more indication: a study of injured worker mortality has been completed.

THE CALL

In 1985, the Actuarial Committee at NCCI resolved to begin such a study with a special call for data. In 1987, the call was submitted to a small group of carriers who agreed to provide such data. In 1988, the call was repeated, but to a larger group of carriers. Submissions were received from 10 carriers in all, most in the second year only.

The specifications for the call and committee sanction for its release were completed in 1986. Data elements, as described below, included several parameters of the claim, to be evaluated at two or more sequential year-end dates.

Exhibit 1 shows the record layout of the call. Report ID, Carrier Code, Claim Number and State would be used for identification. Injury Date and Age at Injury were essential for the study; Pension Date and Sex were desirable, but fortunately not essential, as several carriers did not retain this information in the data files used to answer the call. Type of Benefit code was a simplification of standard NCCI Statistical plan coding. Paid and Incurred amounts of Indemnity and Medical were also not essential, but desirable for corollary studies, and usually easy to capture on company data files. The Reason for Closing field required a choice of only three codes, so was too simplified to allow much analysis. Permanent Total (PT) claims closed for reasons "Other" than fatality had to be handled carefully.

It would probably have been useful to distinguish Occupational Disease from Trauma cases, as allowed in the last entry, but this information was difficult for most companies to provide. In any case, the vast majority of claims reported were traumatic.

The difficulty in identifying certain claim characteristics was not critical in the following sense. The study would attempt to determine the propriety of applying the standard USL tables to the reserves for PT cases. If we study the mortality experience of a random cross section of PT cases, we measure the applicability of the standard tables to the particular group we want, whatever the profile of that group happens to be.

Workers who qualify for a life pension comprise a very select cohort. The potential for permanent injury is not usually recognized at the time of a serious accident. Certainly, no pension is established if the worker dies or, better, recovers within a short time. Even if the adjuster were able to recognize such a condition at an early stage, it usually takes time to convince the central office of the need to classify a claim as PT for the purpose of data reporting, benefit calculation and reserving.

Initially the Special Call required that the earliest report be at least five years subsequent to the accident date. That was later softened so that any claim recognized as PT could be submitted.

Most of the claims submitted were at least four years old; that is, the actual accident had occurred more than four years before the evaluation dates in the call. Many claims were much more mature than that. We assumed we had an unbiased sample of claims set up for lifetime reserves.

The call data did not allow the study of mortality rates for all seriously injured workers. Specifically, we were not able to measure the (presumably high) mortality rate of workers who had just been injured. What we could measure is the mortality rate of workers who live long enough after their serious accident to enter the elite group of lifetime pensioners.

THE DATA

We received data from nine carriers, covering three calendar periods beginning 12/31/83 and ending 12/31/86. We believe the data submitted represented an honest attempt to provide an unbiased sample. Unfortunately, inconsistencies in coding necessitated several assumptions described below.

1) Wrong Benefit Type

   Benefit types 0, 5, 6, 7, 8 or 9 appeared over 3,000 claims. We assumed these were regular statistical plan codes for non-serious losses and did not include them in the study. (Interestingly, inclusion of these claims in the study would increase the sample mortality rate)

2) Reason For Closing Omitted

   There were 1,151 reports with the reason for closing field left blank. We assumed them to be open claims.

3) Multiple Deaths and Life After Death

   A few claims which were closed due to death reappeared, usually closed, but occasionally open. We excluded such subsequent reports.

4) Reopened Claims

222 PT claims closed for reasons other than death (code 3) sometimes appear later as open. These are inferred to be open the whole time.

5) Disappearing Claims

Claims appearing as open in one report may fail to appear in any subsequent report. These were treated as though closed for reasons other than death (code 3) in the subsequent report. There were 801 such claims.

6) Holes

286 claims reported as open in one evaluation disappear the next, but reappear later. These are inferred to be open for the missing evaluation. (One claim skipped over two evaluations, and this gap was filled).

7) Contradictory Age Reports

For example, a claimant may have been reported at 12/31/84 to be 52 and to be 54 at 12/31/85. We chose the lower of the two ages. There were 956 such reports.

Because of these choices, we do not have strong confidence in the statistics derived in the study. Nevertheless, the patterns which emerge may be correct. For the purpose of discussion, we treat the results as valid, as well as outline their economic implications.

Mortality Rates

We first attempted to measure life expectancy of PT claimants using usual loss development triangle techniques. On the advice of a Life Actuary with the Travelers Insurance Company, we realized our folly and shifted to the study of mortality rates by age. There may be a lesson in this.

The data was used to produce empirical mortality rates by age as follows:

1) As of the beginning of each year (previous year end), there would be some number of open PT cases for each age of claimant. Date of injury and age of claimant at injury could then be used to determine age of a pensioner as of the evaluation date. We assumed the last birthday was six months before the accident.

For each age, then, there was a sample of claimants who could be followed through the calendar year to the next evaluation.

2) Claims missing or listed as closed for reasons other than fatality at the next year-end evaluation do not represent a full life. Since the exact date of closure is not coded in the call (and apparently difficult to obtain on company files), it was necessary to assume an average mid-year closing. Using this logic, every claim closed for reasons other than fatality would be counted as one-half a life in the denominator of the mortality rate sample and zero fatalities in the numerator. This is a standard life actuarial technique.

3) The total of claims open for a year or closed due to death, plus half of the claims closed for other reasons, is denoted f_x, the lives at age x.

4) For age group x, we denote the number of deaths as d_x. For a given calendar year the sample mortality rate q_x would be the number of fatalities in that group during the year, divided by the number of lives in the same group so $q_x = d_x/f_x$.

5) The call spanned more than a single calendar year; respondents to the call reported claims evaluated at 12/31/83, '84, '85 and '86 (or some subset of those years, depending on available company data). As such, several calendar years' data could be compiled to evaluate empirical mortality rates. It should be apparent that a single claimant reported as living through several year-

end evaluations would be part of the exposure for age x in the first evaluation, x + 1 in the second, and so on. The first evaluation of a claim did not have to be 12/83, but could be 12/84 or 12/85.

Exhibit 2 shows the data and mortality rates based on this procedure. In the fitting described below, we chose to use only the ages with more than 30 lives, which were 23 to 87.

Average Injured Worker Mortality

The mortality rate on the sample ages 23 to 87, is 0.01943. This is 575 deaths over an exposure of 29586.5 lives, and appears in the first line of Exhibit 2.

With the same exposure by age, the U.S. Life expected mortality is 0.01787, as appears in the first lines of Exhibit 3.

Ignoring for a moment the differences in mortality by age, the binomial standard deviation of the sample mortality rate is:

$$\sqrt{\frac{q(1-q)}{n}} = .0008$$

Using this, we see that the U.S. Life mortality is lower than the sample by nearly two standard deviations.

$$\frac{.01787 - 0.01943}{.0008} = -1.95$$

This would indicate that difference in mortality rates between injured workers and U.S. Life is statistically significant.

THE FORCE OF MORTALITY

A smoothing procedure facilitates the comparison of the resulting sample mortality rates by age to standard. Life actuaries have found that a Makeham curve of the form $M_x = A + BC^x$, *where* M_x *is the force of mortality at age* x, *provides a good fit to* empirical fatality statistics. We fit a Makeham curve to the Injured Worker Mortality data, using a weighted least squares regression.

1) The Makeham force of mortality first must be restated as a mortality rate by age. *This is done as follows:*

$$Q_x = 1 - e^{-\int_x^{x+1} M_t d}$$

$$= 1 - e^{-\int_x^{x+1} A+BC^t \, dt}$$

$$= 1 - e^{-[A+ \frac{B(C-1)\cdot C^x}{\ln C}]}$$

2) For each age x, the differences between the sample, q_x, and the theoretical can be calculated and squared. The weighted sum of squares is then

$$F = \Sigma f_x (q_x - Q_x)^2$$

a function of A, B and C.

3) Since neither Q_x nor $\ln Q_x$ is a linear function of x, minimizing the sum of squared differences must be done using techniques of numerical analysis. We used the SAS package NLIN, which uses the gradient method for finding simultaneous zeros of the partial derivative of F with respect to A, B and C.

4) The fitting described in (2) and (3) weights each age group by the number of lives. It also may be reasonable to weight each sample q_x equally. We did this as well and it leads to a slightly lower fitted force of mortality for injured workers, i.e., closer to U.S. Life.

<u>THE FIT</u>

In fitting the Makeham, we chose to use only the ages in which there were at least 30 lives, 23 to 87. The fit resulted in $A=5.314 \times 10^{-3}$, $B=1.483 \times 10^{-5}$, and $C=1.111$, with rho squared of 94.0%. Exhibit 4-A compares the graph of the mortality rates implied by the fitted curve with the data points.

The standard USL mortality from 1979-81 census data yields an excellent fit to a Makeham curve with parameter A = 7.447×10^{-4}, B = 5.728×10^{-5} , and C = 1.093 with rho squared of 100%. For this fit, we minimized an unweighted sum of squared differences. In most of our analysis, we did not use this latter fit, but used the published values of the commutation function. Exhibit 4-B compares the empirical U.S. Life data with the fitted curve.

SOME CONCLUSIONS

The comparison of the injured worker morality curve with the U.S. Life q_x value in Exhibit 4-C is much more illuminating than a comparison of the raw data points with a curve. The graph shows a mortality rate for injured workers that is slightly higher at ages less than 60, but very slightly lower for the ages 61 to 72.

Is it possible that injured worker mortality is so near standard?

We think it is but it is important to remember the characteristics of the cohort in the study. An injured worker, it must be observed, is healthy enough to have been working in the first place. Such a person not only has demonstrated an ability to survive an accident, but, by the definition of PT status, enjoys an annuity sufficient for lifetime support. The unfortunate worker whose workplace injury results in an immediate death, or one soon enough to preclude the need for a life pension, never enters the study.

A member of this sample population would presumably be resigned to his/her status and under relatively low stress, with the trauma of the original injury well behind. It is also quite probable that older workers may qualify for permanent disability with an injury less severe than that necessary to disable a younger worker. This may in part account for the favorable mortality of workers around the age of retirement.

THE ISSUE OF RESERVING

One of the motivations for this study was a test of the propriety of using Standard US Life Tables to reserve P.T. cases. We observed -- and rationalized -- slight differences in mortality rates by age among injured workers and the general population.

The mortality found in the study implies that the average life pension on injured workers should be 1.7% lower than on standard. This finding is nominally supported by a weighted average of life pensions using sample distributions of permanently injured workers by age and wage level. The analysis is based on data from the call for Detailed Claim Information, and may be seen in Exhibit 5.

Should action be taken on the possible 1.7% overstatement of reserves for injured workers?

Perhaps, but the issue is more complicated than a simple argument about mortality rates. Pensions for permanently injured workers are subject to multiple decrements. Besides fatality, there may well be other reasons for change in claim status. Such claims often change to Permanent Partial if the worker can resume employment in some other capacity. In fact, he may recover completely, and be taken off the pension rolls. In some states, benefits may terminate after some specified period or maximum amount. In most cases, pensions will terminate, or at least be reduced, upon eligibility of the claimant for Social Security. All these things may reduce the need for a full lifetime reserve.

It should be noted that the death of the injured worker may result in a change of claim status to a benefit for the surviving spouse. This is a significant force upward on the required reserve for the permanently injured worker.

Weighing these considerations to decide whether to reduce reserves 1.7% is unnecessary. The loss development analysis done in regular ratemaking almost always indicates upward reserve development. It would not be appropriate to lower reserves still further.

The above concerns pertaining to multiple decrements may indicate a need for further study of the denouement of P.T. claims. Certainly, the process is far more complicated than that contemplated by simple mortality tables. This study is complete, however, in that the mortality rate of pensioned workers has been determined to be hardly different than standard. It also deflates the argument that company reserving is redundant, as may once have been postulated.

The contention that the mortality rate of injured workers is higher than standard is often used in rate hearings as an argument against the need for rate increases: Don't redundant reserves on pensions of short-lived injured workers overstate losses and hence the need for rate relief? Actuaries know that any systematic aggregate reserve redundancy or deficiency will result in measurable patterns of loss development, which in turn will be compensated for in standard methods used to project future ultimate loss levels. In that sense, then, the argument is already fallacious. Now there is direct evidence that the conjecture of high mortality in these cases is false.

ACKNOWLEDGEMENTS

Alan Reynard, FSA, Travelers Insurance Company, gave us advice of significant value.

Leigh Halliwell, NCCI Senior Actuarial Analyst, performed most of the statistical analysis.

Injured Worker Mortality Study
Record Layout

Field Name	Width	Column(s)	Description
Report ID	2	1-2	Calendar Year of report; 1986
Carrier Code	5	3-7	5-digit insurer code number
Claim #	18	8-25	Alpha - numeric code uniquely defining a claim
State	2	26-27	Numeric postal abbreviation for state of jurisdiction determining benefits
Injury Date	6	28-33	Date injury occurred (in MMDDYY format)
Pension Date	6	34-39	Date identified as a pension case (in MMDDYY format)
Age at Injury	2	40-41	Age on date of injury
Sex	1	42	M = male F = female U = unknown
Type of Benefit	1	43	1 = Death 2 = Permanent Total 3 = Permanent Partial 4 = Temporary Total
Medical Paid	7	44-50	Medical benefits paid (whole dollars) as of report date

Field Name	Width	Column(s)	Description
Medical Incurred	7	51-57	Medical benefits incurred (whole dollars) as of report date
Indemnity Paid	7	58-64	Indemnity benefits paid (whole dollars) as of report date
Indemnity Incurred	7	65-71	Indemnity benefits incurred (whole dollars) as of report date
Reason for Closing	1	72	1 = Open claim 2 = Death of claimant 3 = Other
OD/Trauma Code	1	73	1 = Occupational Disease 2 = Traumatic

EXHIBIT 2

INJURED WORKER MORTALITY TABLE

Age (x)	Lives (fx)	Deaths (dx)	QINJWKR (qx)
	29586.5	575	.01943
23	36.5	0	.00000
24	45.5	0	.00000
25	59.0	1	.01695
26	71.0	0	.00000
27	81.5	0	.00000
28	112.5	1	.00889
29	131.0	2	.01527
30	143.5	1	.00697
31	143.0	1	.00699
32	167.5	1	.00597
33	205.0	1	.00488
34	214.0	2	.00935
35	257.0	0	.00000
36	282.5	2	.00708
37	303.5	2	.00659
38	310.5	1	.00322
39	347.0	3	.00865
40	387.5	4	.01032
41	403.0	3	.00744
42	422.5	2	.00473
43	421.0	1	.00238
44	415.5	5	.01203
45	431.5	3	.00695
46	464.5	3	.00646
47	480.5	2	.00416
48	510.0	5	.00980
49	582.5	5	.00858
50	598.0	3	.00502
51	604.5	9	.01489
52	631.0	5	.00792
53	710.0	9	.01268
54	735.0	7	.00952
55	764.5	10	.01308
56	828.0	11	.01329
57	848.5	8	.00943
58	923.0	8	.00867
59	982.0	10	.01018
60	1001.5	13	.01298
61	1017.5	15	.01474
62	1025.5	9	.00878
63	1036.0	9	.00869
64	1006.5	28	.02782
65	961.5	23	.02392
66	902.0	22	.02439
67	849.5	27	.03178
68	820.0	17	.02073
69	766.0	16	.02089
70	708.5	24	.03387
71	624.0	22	.03526
72	564.5	19	.03366

EXHIBIT 2 (CONT'D)

INJURED WORKER MORTALITY TABLE

Age (x)	Lives (fx)	Deaths (dx)	QINJWKR (qx)
73	511.5	15	.02933
74	442.0	20	.04525
75	383.5	14	.03651
76	305.0	23	.07541
77	263.5	14	.05313
78	248.5	16	.06439
79	202.5	17	.08395
80	201.0	16	.07960
81	170.0	14	.08235
82	156.5	14	.08946
83	128.0	9	.07031
84	99.0	10	.10101
85	63.5	5	.07874
86	41.5	5	.12048
87	34.0	8	.23529

EXHIBIT 3

COMPARISON OF INJURED WORKER AND U.S. LIFE MORTALITIES

Age (x)	INJWKR (qx)	INJFIT (Qx)	USLIFE
	.01943	.01944	.01787
23	.00000	.00548	.00134
24	.00000	.00550	.00133
25	.01695	.00552	.00132
26	.00000	.00554	.00131
27	.00000	.00557	.00130
28	.00889	.00560	.00130
29	.01527	.00563	.00131
30	.00697	.00567	.00133
31	.00699	.00571	.00134
32	.00597	.00575	.00137
33	.00488	.00580	.00142
34	.00935	.00586	.00150
35	.00000	.00592	.00159
36	.00708	.00599	.00170
37	.00659	.00607	.00183
38	.00322	.00615	.00197
39	.00865	.00625	.00213
40	.01032	.00636	.00232
41	.00744	.00647	.00254
42	.00473	.00660	.00279
43	.00238	.00675	.00306
44	.01203	.00691	.00335
45	.00695	.00709	.00366
46	.00646	.00729	.00401
47	.00416	.00751	.00442
48	.00980	.00775	.00488
49	.00858	.00802	.00538
50	.00502	.00833	.00589
51	.01489	.00866	.00642
52	.00792	.00904	.00699
53	.01268	.00945	.00761
54	.00952	.00991	.00830
55	.01308	.01042	.00902
56	.01329	.01099	.00978
57	.00943	.01162	.01059
58	.00867	.01232	.01151
59	.01018	.01310	.01254
60	.01298	.01396	.01368
61	.01474	.01492	.01493
62	.00878	.01599	.01628
63	.00869	.01717	.01767
64	.02782	.01848	.01911
65	.02392	.01993	.02059
66	.02439	.02155	.02216
67	.03178	.02334	.02389
68	.02073	.02532	.02585
69	.02089	.02752	.02806
70	.03387	.02996	.03052
71	.03526	.03267	.03315
72	.03366	.03567	.03593

EXHIBIT 3 (CONT'D)

COMPARISON OF INJURED WORKER AND U.S. LIFE MORTALITIES

Age (x)	QINJWKR (qx)	QINJFIT (Qx)	QUSLIFE
73	.02933	.03898	.03882
74	.04525	.04266	.04184
75	.03651	.04673	.04507
76	.07541	.05122	.04867
77	.05313	.05620	.05274
78	.06439	.06170	.05742
79	.08395	.06777	.06277
80	.07960	.07447	.06882
81	.08235	.08185	.07552
82	.08946	.09000	.08278
83	.07031	.09896	.09041
84	.10101	.10881	.09842
85	.07874	.11964	.10725
86	.12048	.13151	.11712
87	.23529	.14452	.12717

EXHIBIT 4-A

Makeham Fit of Injured Worker Mortality

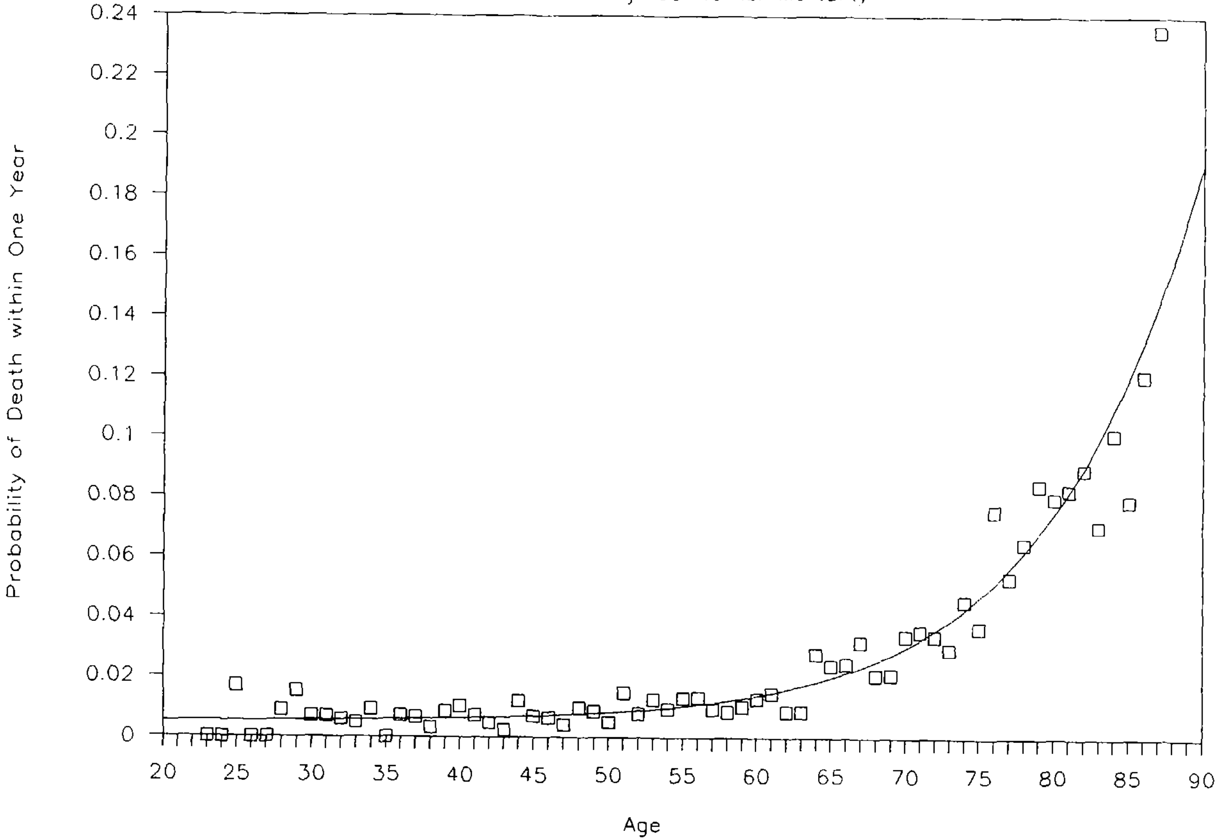

EXHIBIT 4-B

Makeham Fit of U.S. Life Mortality

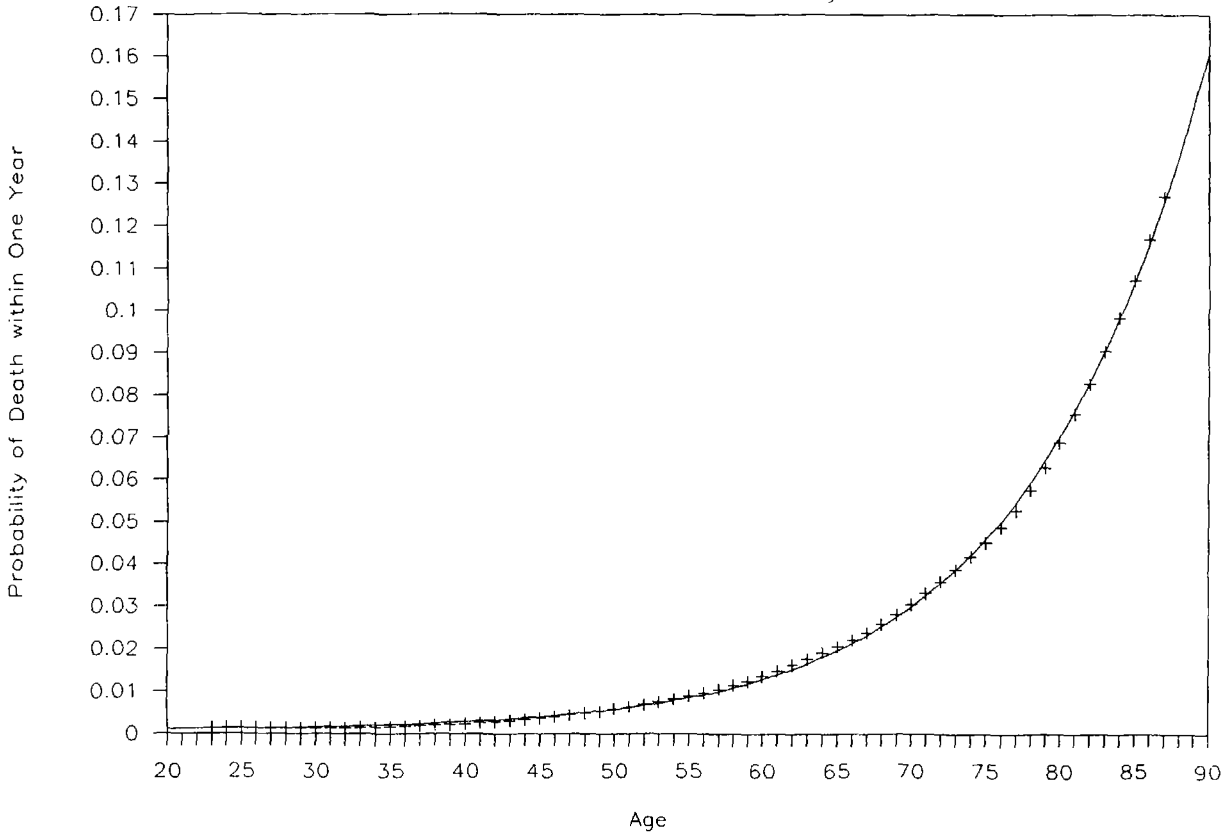

EXHIBIT 4-C

Comparison of Mortalities

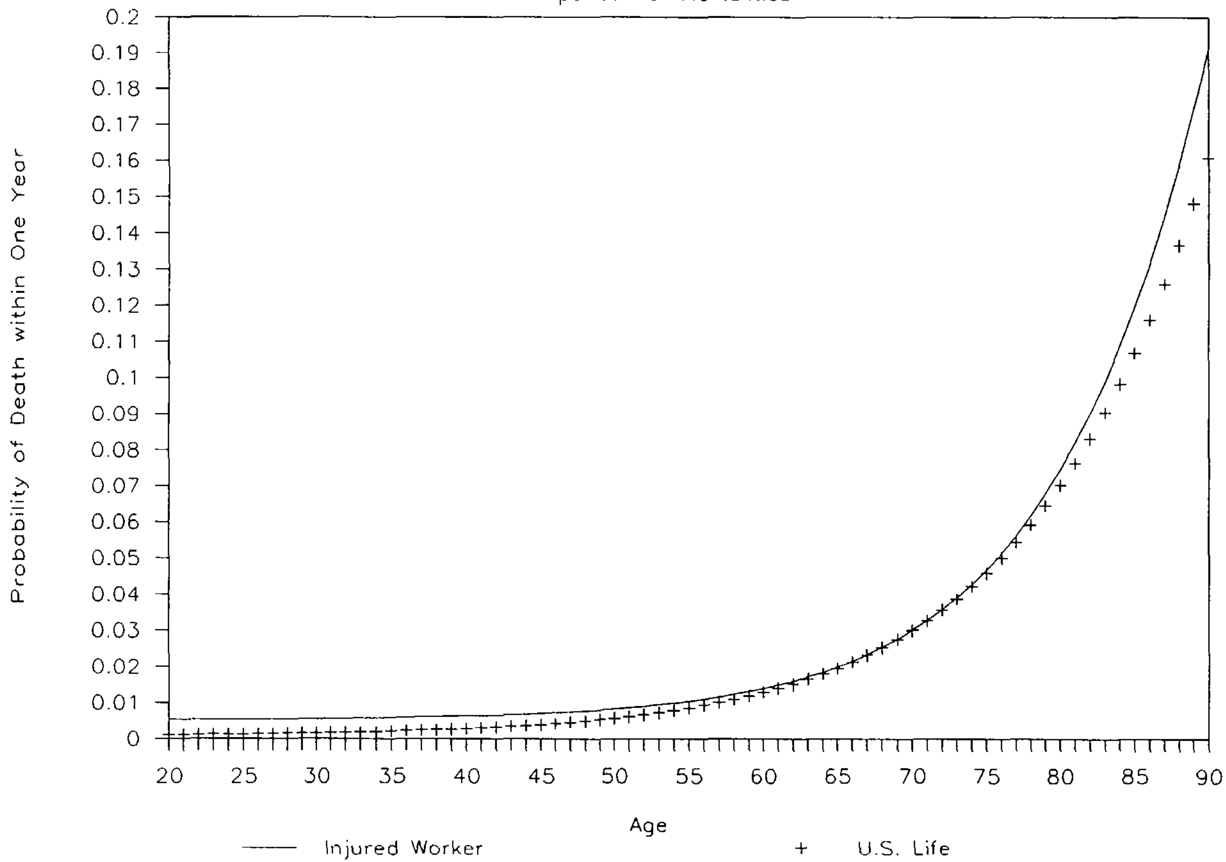

EXHIBIT 5

RESERVES REQUIRED BY U.S. LIFE AND INJURED WORKER MORTALITIES
FOR A SAMPLE OF PENSIONED INJURED WORKERS
(Interest Rate=6.0%)

Age	Injured Workers	Average Annual Benefit	US Life Annuity	Inj Wkr Annuity
21	2	$9,641	15.607	14.782
22	1	$9,360	15.562	14.749
23	9	$9,363	15.515	14.713
24	14	$9,516	15.465	14.676
25	24	$9,219	15.412	14.636
26	34	$9,147	15.355	14.594
27	35	$9,792	15.295	14.549
28	64	$10,117	15.230	14.502
29	65	$10,561	15.162	14.452
30	64	$10,327	15.089	14.398
31	77	$10,365	15.012	14.342
32	89	$10,648	14.931	14.283
33	116	$11,098	14.844	14.220
34	106	$11,635	14.753	14.154
35	136	$11,503	14.658	14.084
36	156	$11,649	14.558	14.011
37	152	$11,767	14.453	13.933
38	148	$11,932	14.343	13.851
39	171	$12,156	14.228	13.765
40	189	$12,862	14.109	13.674
41	197	$12,611	13.984	13.579
42	199	$12,582	13.855	13.478
43	189	$13,045	13.721	13.373
44	194	$13,306	13.582	13.262
45	216	$13,139	13.437	13.146
46	229	$13,571	13.288	13.024
47	222	$13,467	13.134	12.896
48	268	$13,366	12.975	12.763
49	290	$13,785	12.812	12.623
50	258	$13,496	12.644	12.477
51	286	$13,367	12.472	12.325
52	296	$13,419	12.295	12.167
53	336	$13,607	12.113	12.001
54	337	$13,694	11.926	11.829
55	356	$13,631	11.735	11.651
56	387	$13,669	11.538	11.465
57	369	$13,439	11.337	11.273
58	449	$13,426	11.131	11.074
59	449	$13,459	10.920	10.869
60	432	$13,546	10.705	10.656
61	444	$13,433	10.487	10.437
62	464	$13,465	10.266	10.212
63	449	$13,127	10.042	9.981
64	429	$13,078	9.815	9.743
65	384	$12,930	9.584	9.500
66	358	$12,597	9.349	9.251
67	342	$12,347	9.110	8.997
68	351	$12,319	8.866	8.739

EXHIBIT 5 (CONT'D)

RESERVES REQUIRED BY U.S. LIFE AND INJURED WORKER MORTALITIES
FOR A SAMPLE OF PENSIONED INJURED WORKERS
(Interest Rate=6.0%)

Age	Injured Workers	Average Annual Benefit	US Life Annuity	Inj Wkr Annuity
69	288	$11,778	8.620	8.476
70	261	$11,768	8.372	8.209
71	233	$11,406	8.122	7.940
72	201	$11,178	7.872	7.667
73	188	$10,738	7.620	7.392
74	155	$10,464	7.367	7.116
75	126	$10,141	7.111	6.838
76	104	$10,063	6.852	6.561
77	100	$9,678	6.591	6.284
78	95	$9,351	6.329	6.008
79	70	$9,400	6.068	5.734
80	78	$8,634	5.809	5.462
81	59	$8,256	5.556	5.194
82	58	$8,465	5.309	4.930
83	40	$7,869	5.069	4.670
84	21	$7,691	4.836	4.416
85	16	$7,275	4.609	4.167
86	11	$6,804	4.390	3.925
87	14	$7,481	4.181	3.690
88	9	$6,333	3.982	3.463
89	3	$7,041	3.788	3.243
90	3	$6,881	3.599	3.032
91	4	$7,043	3.416	2.829
92	4	$6,555	3.244	2.634
93	1	$6,803	3.086	2.449
95	2	$5,914	2.810	2.105
96	2	$4,994	2.694	1.947
97	1	$5,481	2.591	1.797
99	1	$5,406	2.415	1.525
100	1	$5,323	2.341	1.401
	======	=======	======	======
	12,981	$12,563	11.196	11.004

Relative Difference = (Avg Inj Wkr/Avg US Life)-1 = -1.7%