RATING BY LAYER OF INSURANCE

RUTH E. SALZMANN

One of the peculiarities of property and casualty insurance is that losses vary by size depending upon the severity of the accident, occurrence, or illness. The insured amount, or limit of liability, is a maximum benefit and is paid only in the event of a very serious or total loss. For the most part, losses are settled for less than the maximum benefit. Because of this "partial loss" feature, an increase or decrease in the insured amount for any one risk does not necessitate a proportional change in the premium charge. This nonproportional or non-linear relationship gives rise to many rating complications, especially when it is coupled with a limitation on the amount of coverage afforded.

Limitations on amounts insured can take many forms. Deductibles, franchises, excess coverage, retentions, coinsurance, and maximums are all ways of limiting coverage. To properly evaluate the cost of the limited insurance protection, it becomes necessary to measure either the proportion of losses eliminated or the proportion of losses remaining. If the forms of limited coverage were standardized, rates could be determined by class rating, simply by adding another set of classification codes. Such a solution would suffer the injustices of all class rating methods which by definition are designed to produce the proper rate for the class (the group to which the risk is assigned) rather than a proper rate for the individual risk itself. But more important, such a solution would not produce the desired flexibility. When limited amounts of insurance protection are sold, it is usually for the purpose of satisfying the individual insured's needs. Thus it is very important that the rating system afford maximum flexibility.

Such flexibility can be accomplished by a method which I propose to call "Rating by Layer of Insurance." This method requires that we measure or evaluate the proportion of losses which fall in each layer of insurance protection. These proportions can be established by analyzing losses by size of loss from which accumulated loss cost distributions can be developed.

The mechanics of developing such distributions are relatively simple, and will be discussed later in the paper. The difficulty in this method of rating is getting the right distribution for the rating problem at hand. In other words, a size of loss distribution developed from one population of risks may not be appropriate for another population of risks. Each size of loss distribution is dependent upon the characteristics inherent in the collection of risks generating the losses. Thus it is necessary to be acquainted with the spread of exposures producing the size of loss distribution before any application of the results can be made. For instance, in major medical insurance we do not expect that the first $200 of benefits will cost the same for a man as for a woman, for an old person as for a young, for a high income person as for a low, for a New York City resident as for a resident of Highland, Wisconsin, nor do we expect that the first $200 will be the same proportion of the total cost for these respective individuals. In fire insurance, we do not expect that the first $1,000 of protection will cost the same for a $50,000 house as for a $10,000 house, for a frame house as for a brick, for a protected house as for an unprotected one, nor do we expect that the first $1,000 will be the same proportion of the total cost for these respective houses.

Because of these complications it is easy to understand why most size of loss distributions are of limited value and are only appropriate for the collection of risks which generated the losses. Perhaps this explains why so little size-of-loss data has been published. (The one major exception to this general situation is the continuation tables used in A & H insurance.) In any event, there are many complications and dangers inherent in this rating approach. No doubt the rating by layer of insurance from accumulated loss cost distributions is a long way off, but the challenge in exploring its possibilities is most inviting.

For this reason I undertook a study about two years ago to determine whether size of loss distributions bore any direct relationship to "amounts at risk."

In making this study it was necessary to select data which would be relatively pure; that is, free from the influence of unrelated factors. I therefore selected the Homeowners line of business where the insured value, or policy amount, would be a fair approximation of amount at risk. It was expected that under-insurance, if any, would be relatively consistent by class. Any under-insurance in Homeowners should be rather minimal because of the type of risk insured. The homes are relatively new and probably subject to mortgage. In addition to these risk characteristics, the Homeowner policy has a built-in incentive to fully insure because of the replacement cost clause, which comes into operation when the insured value equals 80% of the replacement cost.

And for the losses, I used fire building losses only, excluding contents. It was expected that these losses would have the most direct relationship with policy amount and thus provide the best basis for the study. Also in Homeowners, there is only one policy and one company per insured which eliminates the problem of apportioned or pro rata direct losses.

The study itself included the direct loss data of the Insurance Company of North America (INA) for 1960 incurred year as of May 31, 1961. This data was summarized by claim number so as to accumulate multiple payments on closed claims and accumulate payments with loss reserves on open claims. The total loss for each claim was then ratioed to the amount of insurance on the policy affording the coverage. (The insured amount was available from the statistical code on the loss cards.) The end result was that there was one card with all pertinent data for each claim.

Individual listings of these loss cards were then tabulated for each insured (policy) amount within each construction-protection class; and accumulated loss cost distributions were developed by "% of insured value." The mechanics of developing these distributions are not difficult especially when the loss data is in the form already described. (Although the C exhibits will be discussed later, the reader may wish to refer to them now because they illustrate the method used.) First, the individual losses are accumulated upward by "% of insured value." This produces an accumulated size of loss distribution from which we can derive the cost of losses not greater than X%. To get the total cost of losses for the layer of insurance up to X%, it is necessary to add to the size of loss data, the loss dollars up to X% in those losses which exceed X%. This is accomplished by multiplying the sum of the policy amounts for losses exceeding X% by X%. The total of these two sets of data:

1. Those losses not greater than X%, and
2. The first X% included in those losses exceeding X% then gives us an accumulated loss cost distribution from which we can derive the cost of losses by layer of insurance.

When these distributions were calculated for the four most popular policy amounts within each protection-construction class, there was little variation by policy amount, thereby indicating a direct relationship between the loss cost distributions and amounts at risk. This comparison is set forth in Exhibit A.

Because this relationship did exist, all policy amounts were consolidated into one accumulated loss cost distribution for each of the four generally used construction-protection classifications: frame-protected, brick-protected, frame-unprotected, brick-unprotected. Graphs showing these distributions are set forth in Exhibits B and B-1. The actual data was then graduated by the method of adjusting second differences to an orderly downward progression. In addition, the brick-protected distribution was adjusted so that the increments in the upper portion of the distribution were no greater than those in the frame-protected distribution. This adjustment was made entirely on the basis of the author's judgment. Exhibits C-1, C-2, C-3 and C-4 set forth these accumulated loss cost distributions and their respective derivations.

In order to rate by layer of insurance, it is necessary to have accumulated loss cost distributions similar to those included in the C exhibits. Examples of how they can be used are set forth below: (The illustrations will be based on Exhibit C-1, thus confining the examples to the building fire peril in the frame-protected classification.)

a. A deductible of 2% of total value — Coverage in this instance would be limited to the proportion of all losses in excess of 2% of the total value of the building. From the accumulated loss cost distribution in column 8, the cost for the layer of insurance eliminated is 29.5% of the cost for full coverage. Thus the credit for a 2% deductible would be 29.5% of the pure premium for full coverage.
b. A maximum benefit equal to 70% of the total value — This coverage eliminates the proportion of losses in excess of 70% of the

total value. The cost for the layer of insurance eliminated is equivalent to 4.6% of the cost for full coverage. (100.0 − 95.4 in column 8.) Thus the credit for this limited coverage would be 4.6% of the pure premium for full coverage. These percentages could also be used for a building with a market value equal to 70% of its replacement cost.

These examples illustrate the promulgation of pure premiums for various layers of insurance via accumulated loss cost distributions. Another example of limited coverage is the franchise clause in property coverages. Although this is not a direct application of the "rating by layer of insurance" method, rates can be derived as a by-product from the data collected. Therefore the following illustration is also included:

c. A franchise of 5% of total value–Coverage in this instance eliminates all losses which are 5% or less of the total value of the building; the full amount of all losses in excess of 5% is paid. From the accumulated size of loss distribution in column 3, the proportion of losses equal to or less than 5% is 28.2% ($559,257 ÷ $1,981,703). Thus the credit for a 5% franchise would be 28% of the pure premium for full coverage.

This completes the explanation of the study itself.

The benefits of the study are two-fold. First, the results showed that there was a direct relationship between loss cost distributions and amounts at risk. Although this conclusion is what we might have expected, it is interesting to learn that such a premise can be substantiated. The other advantage of the study is in the value of the loss cost distributions themselves. There may be few direct applications of the loss cost data, but such statistics could well serve as a useful yardstick in evaluating other fragmentary size of loss data. At INA, these distributions have been helpful in determining excess of loss quotas, CML experience rating plan credibilities, and credits for deductibles in yacht insurance.

The door is open for many other studies on this general subject. It would be of interest, for instance, if someone could show via this technique that the loss constant method of rating dwellings in the fire field was the equivalent of a fixed charge for the first $X of loss and a variable charge (varying by amount of insurance) for the coverage in excess of $X.

In the reinsurance area, the potential for further exploration in rating by layer of insurance is tremendous. Here a significant contribution could be made if we could isolate sufficient characteristics in the primary carrier's book of business to establish a size of loss distribution that would be appropriate for the collection of risks involved. As reinsurance problems embrace only the upper limits of accumulated loss cost distributions, it may be possible to study such distributions in reverse, from the top down so to speak. In Mr. Longley-Cook's paper, "A Statistical Study of Large Fire Losses with

Application to a Problem in Catastrophe Insurance" (1952 *PCAS,* p. 77), the study was limited to large losses from which a graduated distribution of excess loss costs was developed.

Additional large loss studies may well disclose the existence of a relatively uniform slope in the upper portion of the loss cost curve, thus making it possible to do some reasonably accurate curve fitting for a particular collection of risks after one or two points on the curve can somehow be determined. At the Reinsurance Seminar for our November 1961 meeting (1961 *PCAS,* p. 211), I suggested that the Xth largest loss might serve as such a rating tool. Such a plan is now being tested, where X equals the 3rd largest loss per million dollars of the primary carrier's base premiums subject to the reinsurance cover. This plan incorporates formulas which, when the value of the 3rd largest loss is introduced, will produce expected loss costs (applicable to the experience period involved) for various retentions.

The material presented in this paper should make it abundantly clear that there are many challenges in the rating of nonproportional insurance when limited coverage is made available to the insured. It is hoped that this paper will encourage others to make further studies in this mostly unexplored area.

Exhibit A

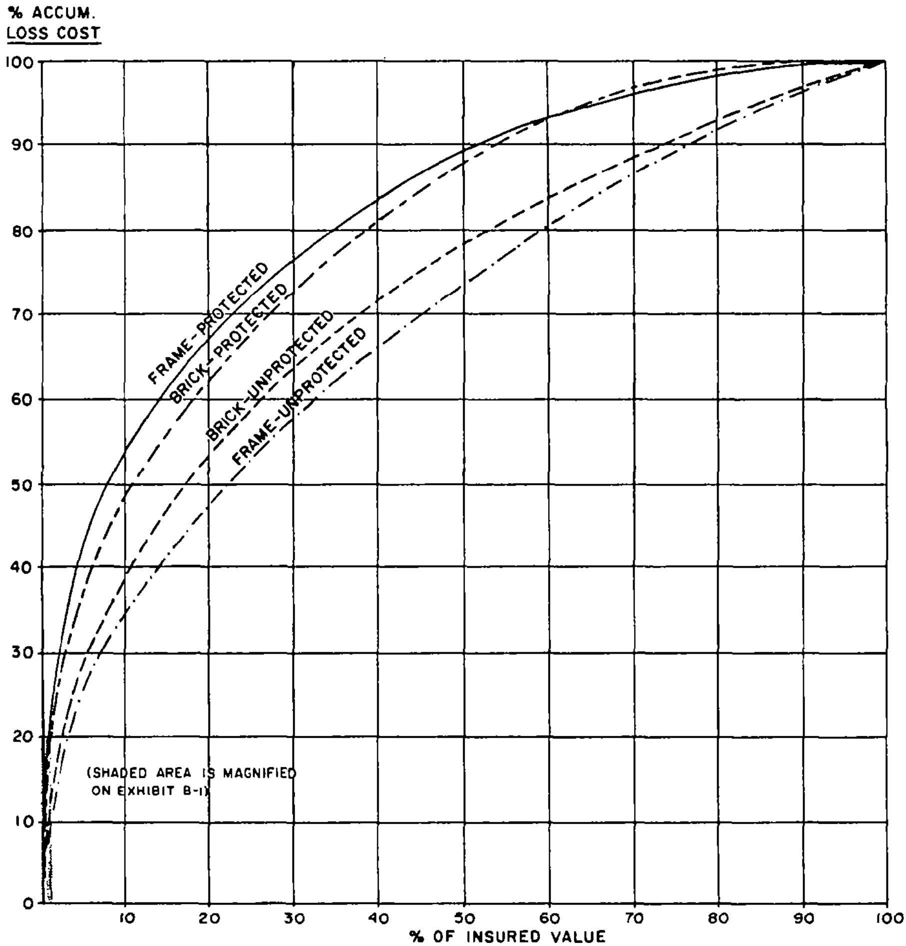
HOMEOWNERS BUILDING FIRE LOSSES
ACCUMULATED LOSS COST DISTRIBUTIONS BY % OF INSURED VALUE
PROTECTED CLASSES

% Of Insured Value	Frame Construction Policy Amount (in thous.)				Brick Construction Policy Amount (in thous.)			
	10	15	20	25	10	15	20	25
0.0 – 1.0	21.0	20.7	25.5	19.3	16.8	19.3	31.7	15.7
0.0 – 2.0	30.3	28.8	35.9	25.8	24.4	26.0	43.7	20.1
0.0 – 3.0	35.9	34.0	42.2	29.6	28.3	29.7	51.7	23.2
0.0 – 4.0	40.3	37.7	46.8	32.7	31.3	32.6	57.2	25.8
0.0 – 5.0	44.0	40.6	50.5	35.3	34.1	35.3	61.9	28.2
0.0 – 6.0	47.1	43.0	53.7	37.7	36.9	37.5	66.3	30.3
0.0 – 7.0	49.8	45.2	56.4	39.9	39.3	39.5	70.0	32.1
0.0 – 8.0	52.1	47.2	58.7	42.1	41.2	41.5	72.9	33.6
0.0 – 9.0	53.7	49.0	60.8	44.0	43.0	43.6	75.8	35.0
0.0 – 10.0	53.1	50.6	62.7	45.7	44.5	45.3	78.4	36.4
0.0 – 12.5	61.0	54.5	66.5	49.5	47.0	49.1	82.1	40.0
0.0 – 15.0	64.8	57.6	69.5	53.2	49.1	52.1	84.3	43.6
0.0 – 20.0	70.9	62.9	73.5	60.1	53.4	57.9	87.3	49.4
0.0 – 25.0	76.3	67.3	76.7	65.7	57.5	63.6	89.1	55.1
0.0 – 30.0	81.0	71.0	79.7	69.8	60.3	69.1	90.8	60.7
0.0 – 40.0	86.8	77.6	85.6	76.3	66.0	78.1	94.4	68.1
0.0 – 50.0	90.1	83.0	89.8	81.5	71.6	86.8	97.9	73.9
0.0 – 60.0	92.7	87.9	93.8	86.6	77.3	94.2	100.0	79.6
0.0 – 70.0	95.3	92.2	96.5	91.8	83.0	98.0	100.0	85.3
0.0 – 80.0	97.0	95.8	98.4	96.0	88.7	99.8	100.0	91.1
0.0 – 90.0	98.6	98.3	99.8	98.4	94.3	100.0	100.0	96.8
0.0 – 100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
# of losses	674	763	478	226	103	252	176	125

Source: INA experience for 1960 incurred year developed as of 5/31/61

EXHIBIT B

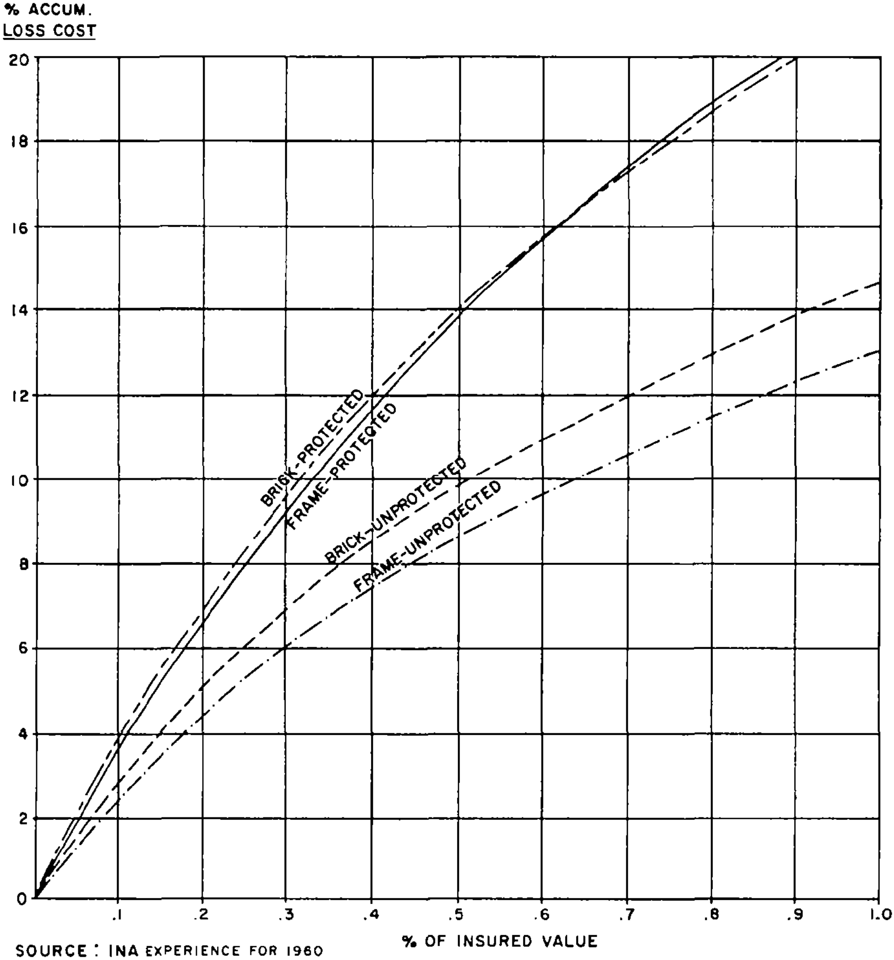
HOMEOWNERS BUILDING FIRE LOSSES
ACCUMULATED LOSS COSTS BY % OF INSURED VALUE



SOURCE: INA EXPERIENCE FOR 1960
INCURRED YEAR DEVELOPED AS OF 5/31/61

EXHIBIT B-1

HOMEOWNERS BUILDING FIRE LOSSES — ACCUMULATED LOSS COSTS BY % OF INSURED VALUE ENLARGEMENT OF SHADED AREA IN EXHIBIT B



SOURCE: INA EXPERIENCE FOR 1960 INCURRED YEAR DEVELOPED AS OF 5/31/61

Exhibit C-1

HOMEOWNERS BUILDING FIRE LOSSES
ACCUMULATED LOSS COST DISTRIBUTION BY % OF INSURED VALUE
FRAME-PROTECTED CLASSIFICATION

1 X% of Insured Value	2 Losses ≦ X% #	3 $	4 Losses > X% $	5 1st X% in Losses > X%	6 Total Cost 1st X% (3) + (5)	7 % Distribution of Column 6 Actual	8 Graduated
.1	546	$ 6,670	$1,975,033	69,011	75,681	3.82	3.9
.2	1,157	21,949	1,959,754	111,120*	133,069	6.71	7.0
.3	1,659	41,658	1,940,045	145,432*	187,090	9.44	9.6
.4	2,041	63,304	1,918,399	170,625*	233,929	11.80	11.9
.5	2,338	84,543	1,897,160	190,620*	275,163	13.89	13.9
.6	2,610	109,067	1,872,636	202,594*	311,661	15.73	15.7
.7	2,833	130,681	1,851,022	213,452*	344,133	17.37	17.4
.8	3,003	150,684	1,831,019	222,922*	373,606	18.85	19.0
.9	3,151	170,273	1,811,430	230,288*	400,561	20.21	20.5
1.0	3,310	194,386	1,787,317	233,380	427,766	21.59	21.9
1.5							26.0
2.0	3,981	340,500	1,641,203	257,980	598,480	30.20	29.5
2.5							32.6
3.0	4,256	438,598	1,543,105	266,910	705,508	35.60	35.4
4.0	4,388	504,344	1,477,359	280,520	784,864	39.61	40.1
5.0	4,474	559,257	1,422,446	289,450	848,707	42.83	43.8
6.0	4,520	594,585	1,387,118	308,580	903,165	45.58	46.7
7.0	4,554	626,163	1,355,540	325,500	951,663	48.02	49.0
8.0	4,585	657,956	1,323,747	337,920	995,876	50.25	50.9
9.0	4,605	688,148	1,293,555	348,390	1,036,538	52.31	52.6
10.0	4,636	735,442	1,246,261	338,400	1,073,842	54.19	54.2
15.0							61.5
20.0	4,730	903,986	1,077,717	431,000	1,334,986	67.37	67.4
30.0	4,767	1,039,020	942,683	483,000	1,522,020	76.80	76.9
40.0	4,794	1,195,005	786,698	468,400	1,663,405	83.94	83.9
50.0	4,810	1,363,855	617,848	400,000	1,763,855	89.01	89.0
60.0	4,818	1,436,391	545,312	400,800	1,837,191	92.71	92.7
70.0	4,828	1,559,165	422,538	333,200	1,892,365	95.49	95.4
80.0	4,837	1,664,088	317,615	269,600	1,933,688	97.58	97.4
90.0	4,843	1,742,466	239,237	220,500	1,962,966	99.05	98.9
100.0	4,862	1,981,703	0	0	1,981,703	100.00	100.0

* Slight error in programming set X to be .19, .29, ... and .89 rather than .2, .3, ... and .9

Source: INA experience for 1960 incurred year developed as of 5/31/61

Exhibit C-2

HOMEOWNERS BUILDING FIRE LOSSES
ACCUMULATED LOSS COST DISTRIBUTION BY % OF INSURED VALUE
BRICK-PROTECTED CLASSIFICATION

1	2	3	4	5	6	7	8
X% of Insured Value	Losses ≦ X% #	Losses ≦ X% $	Losses > X% $	1st X% in Losses > X%	Total Cost 1st X% (3) + (5)	% Distribution of Column 6 Actual	% Distribution of Column 6 Graduated**
.1	210	$ 3,079	$692,043	24,953	28,032	4.03	4.1
.2	398	8,822	686,300	39,723*	48,545	6.98	7.2
.3	561	17,327	677,795	50,205*	67,532	9.72	9.7
.4	670	25,039	670,083	58,590*	83,629	12.03	12.0
.5	762	34,059	661,063	63,519*	97,578	14.04	14.1
.6	840	42,048	653,074	67,744*	109,792	15.79	16.0
.7	916	52,280	642,842	68,117*	120,397	17.32	17.7
.8	964	59,077	636,045	70,729*	129,806	18.67	19.2
.9	998	63,561	631,561	74,885*	138,446	19.92	20.6
1.0	1,047	73,182	621,940	74,010	147,192	21.17	21.9
1.5							26.0
2.0	1,243	122,800	572,322	75,900	198,700	28.58	29.5
2.5							32.6
3.0	1,307	151,770	543,352	78,330	230,100	33.10	35.4
4.0	1,330	169,337	525,785	84,000	253,337	36.44	40.1
5.0	1,344	185,830	509,292	87,450	273,280	39.31	43.8
6.0	1,353	193,237	501,885	96,720	289,957	41.71	46.7
7.0	1,361	202,907	492,215	102,410	305,317	43.92	49.0
8.0	1,370	217,817	477,305	101,360	319,177	45.92	50.9
9.0	1,373	220,260	474,862	111,420	331,680	47.72	52.6
10.0	1,381	232,633	462,489	110,900	343,533	49.42	54.2
15.0							61.5
20.0	1,400	286,567	408,555	143,400	429,967	61.85	67.4
30.0	1,406	324,880	370,242	173,700	498,580	71.73	76.9
40.0	1,411	353,253	341,869	200,400	553,653	79.65	83.9
50.0	1,415	392,934	302,188	208,000	600,934	86.45	89.0
60.0	1,421	459,427	235,695	179,400	638,827	91.90	92.7
70.0	1,424	485,723	209,399	181,300	667,023	95.96	95.4
80.0	1,427	615,100	80,022	68,000	683,100	98.27	97.4
90.0	1,428	627,322	67,800	63,000	690,322	99.31	98.9
100.0	1,432	695,122	0	0	695,122	100.00	100.0

* Slight error in programming set X to be .19, .29, ... and .89 rather than .2, .3, ... and .9

**This distribution is the same as the graduated distribution for the frame-protected classification from 1.0% on. Such an adjustment was made to avoid higher burning costs for the brick-protected classification in the upper layers of insurance.

Source: INA Experience for 1960 incurred year developed as of 5/31/61.

Exhibit C-3

HOMEOWNERS BUILDING FIRE LOSSES
ACCUMULATED LOSS COST DISTRIBUTION BY % OF INSURED VALUE
FRAME-UNPROTECTED CLASSIFICATION

1	2	3	4	5	6	7	8
X% of Insured Value	Losses ≦ X% #	Losses ≦ X% $	Losses > X% $	1st X% in Losses > X%	Total Cost 1st X% (3) + (5)	% Distribution of Column 6 Actual	% Distribution of Column 6 Graduated
.1	169	$ 1,981	$724,838	16,609	18,590	2.56	2.7
.2	383	6,508	720,311	25,591*	32,099	4.42	4.6
.3	547	12,181	714,638	32,155*	44,336	6.10	6.1
.4	662	17,921	708,898	36,516*	54,437	7.49	7.4
.5	733	22,407	704,412	40,837*	63,244	8.70	8.6
.6	811	28,561	698,258	42,386*	70,947	9.76	9.7
.7	867	33,662	693,157	44,036*	77,698	10.69	10.7
.8	902	36,884	689,935	46,966*	83,850	11.54	11.6
.9	937	40,538	686,281	49,039*	89,577	12.32	12.4
1.0	968	45,095	681,724	50,290	95,385	13.12	13.1
1.5							16.1
2.0	1,095	71,776	655,043	62,640	134,416	18.49	18.5
2.5							20.5
3.0	1,170	97,626	629,193	62,700	160,326	22.06	22.1
4.0	1,203	111,014	615,805	68,160	179,174	24.65	24.7
5.0	1,217	118,496	608,323	77,050	195,546	26.90	26.9
6.0	1,224	123,584	603,235	86,760	210,344	28.94	28.9
7.0	1,237	134,806	592,013	89,180	223,986	30.82	30.8
8.0	1,239	136,021	590,798	100,640	236,661	32.56	32.6
9.0	1,240	137,093	589,726	112,140	249,233	34.29	34.3
10.0	1,254	157,020	569,799	104,100	261,120	35.93	35.9
15.0							42.9
20.0	1,272	199,581	527,238	148,000	347,581	47.82	48.7
30.0	1,280	222,237	504,582	195,300	417,537	57.45	58.4
40.0	1,287	250,895	475,924	226,800	477,695	65.72	67.0
50.0	1,294	287,097	439,722	245,000	532,097	73.21	73.6
60.0	1,298	306,751	420,068	271,800	578,551	79.60	80.3
70.0	1,300	318,378	408,441	304,500	622,878	85.70	86.2
80.0	1,305	371,421	355,398	292,000	663,421	91.28	91.4
90.0	1,308	419,090	307,729	276,300	695,390	95.68	96.0
100.0	1,333	726,819	0	0	726,819	100.00	100.0

* Slight error in programming set X to be .19, .29, ... and .89 rather than .2, .3, ... and .9

Source: INA experience for 1960 incurred year developed as of 5/31/61

Exhibit C-4

HOMEOWNERS BUILDING FIRE LOSSES
ACCUMULATED LOSS COST DISTRIBUTION BY % OF INSURED VALUE
BRICK-UNPROTECTED CLASSIFICATION

1	2	3	4	5	6	7	8
X% of Insured Value	Losses ≦ X% #	$	Losses > X% $	1st X% in Losses > X%	Total Cost 1st X% (3) + (5)	% Distribution of Column 6 Actual	Graduated
.1	54	$ 815	$220,576	5,698	6,513	2.94	2.9
.2	120	2,656	218,735	8,436*	11,092	5.01	5.1
.3	155	4,257	217,134	10,968*	15,225	6.88	6.9
.4	191	6,025	215,366	12,695*	18,720	8.46	8.4
.5	218	8,131	213,260	13,563*	21,694	9.80	9.7
.6	237	10,013	211,378	14,308*	24,321	10.99	10.9
.7	248	11,171	210,220	15,449*	26,620	12.02	12.0
.8	257	12,431	208,960	16,361*	28,792	13.01	13.0
.9	272	15,013	206,378	15,646*	30,659	13.85	13.9
1.0	280	15,937	205,454	16,600	32,537	14.70	14.7
1.5							17.9
2.0	323	27,084	194,307	18,140	45,224	20.43	20.4
2.5							22.3
3.0	344	34,309	187,082	18,120	52,429	23.68	23.7
4.0	349	36,438	184,953	21,800	58,238	26.31	26.4
5.0	351	37,544	183,847	26,100	63,644	28.75	28.8
6.0	353	38,645	183,746	30,180	68,825	31.09	31.1
7.0	356	41,780	179,611	31,990	73,770	33.32	33.3
8.0	356	41,780	179,611	36,560	78,340	35.39	35.4
9.0	358	45,229	176,162	37,530	82,759	37.38	37.4
10.0	362	52,429	168,962	34,400	86,829	39.22	39.3
15.0							46.5
20.0	366	63,147	158,244	52,400	115,547	52.19	52.6
30.0	370	82,703	138,688	57,000	139,703	63.10	62.9
40.0	372	94,317	127,074	62,000	156,317	70.61	71.0
50.0	373	98,971	122,420	72,500	171,471	77.45	77.5
60.0	374	123,227	98,164	60,000	183,227	82.76	82.9
70.0	374	123,227	98,164	70,000	193,227	87.28	87.6
80.0	374	123,227	98,164	80,000	203,227	91.80	91.9
90.0	375	131,391	90,000	81,000	212,391	95.93	96.0
100.0	378	221,391	0	0	221,391	100.00	100.0

* Slight error in programming set X to be .19, .29, ... and .89 rather than .2, .3, ... and .9

Source: INA experience for 1960 incurred year developed as of 5/31/61