was concerns regarding the transition. Instead, the rating variables and rating algorithm were adjusted to address the inequities. This debate over the choice of workers compensation exposure base continues to reemerge.

The following table shows the exposure bases currently used for different lines of business. Multi-peril package policies such as commercial general liability use different exposure bases for pricing different aspects of the package policy.

4.1 Typical Exposure Bases

Line of Business	Typical Exposure Bases
Personal Automobile	Earned Car Year
Homeowners	Earned House Year
Workers Compensation	Payroll
Commercial General Liability	Sales Revenue, Payroll , Square Footage, Number of Units
Commercial Business Property	Amount of Insurance Coverage
Physician's Professional Liability	Number of Physician Years
Professional Liability	Number of Professionals (e.g., Lawyers or Accountants)
Personal Articles Floater	Value of Item

EXPOSURES FOR LARGE COMMERCIAL RISKS

Large commercial risks present unique challenges for ratemaking and for the use of more conventional exposure bases. As a result, ratemaking for large commercial risks is often done via composite rating and loss-rated composite rating.

Composite rating is used for some large commercial risks when the amount of exposure is difficult to track throughout the policy period. For example, some commercial multi-peril policies use different exposure measures for each aspect of coverage (e.g., sales revenue for general liability, amount of insurance or property value for commercial business property). The policy premium is initially calculated using estimates for each exposure measure along with the relevant rating algorithms for each coverage. These individual exposure estimates, however, are expected to change throughout the course of the policy term. Rather than auditing each exposure measure, a proxy measure is used to gauge the overall change in exposure to loss. For example, if property value is chosen as the proxy exposure measure, a 20% increase in property value during the policy term would trigger a premium adjustment of 20% for the whole policy's premium.

In loss-rated composite rating, premium is calculated based on the individual risk's historical loss experience (i.e., without any use of standard rating algorithms). In that case, the implicit exposure base is the risk. This rating technique is discussed in more detail in Chapter 15.

AGGREGATION OF EXPOSURES

Methods of Aggregation for Annual Terms

As described in Chapter 3, four common methods of data aggregation are calendar year, accident year, policy year, and report year. In regards to aggregating exposures, there are only two methods applicable: calendar year (which is the same as calendar-accident year) and policy year.

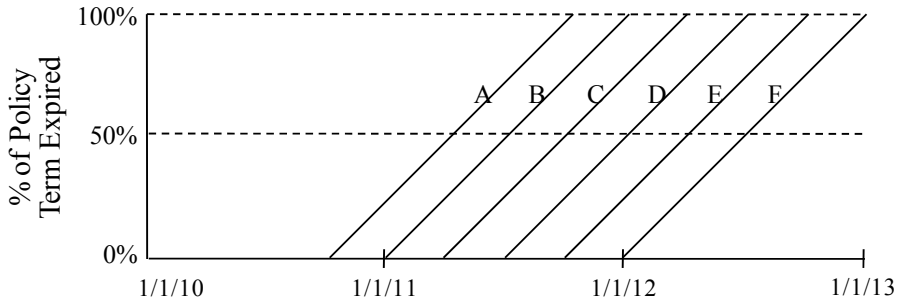
Example policies will be used to demonstrate these concepts. For simplicity, the example chosen (homeowners insurance) uses policies for which there is generally one exposure per policy. These example policies have annual terms; examples using semi-annual terms will be provided later in this chapter.

4.2 Policies

Policy	Effective Date	Expiration Date	Exposure
A	10/01/10	09/30/11	1.00
B	01/01/11	12/31/11	1.00
C	04/01/11	03/31/12	1.00
D	07/01/11	06/30/12	1.00
E	10/01/11	09/30/12	1.00
F	01/01/12	12/31/12	1.00

The aforementioned policies can be represented pictorially (see Figure 4.3). The x-axis represents time, and the y-axis represents the percentage of the policy term that has expired.[8] Each diagonal line represents a different policy. At the onset of the policy, 0% of the policy term has expired; thus, that point is located on the lower x-axis at the effective date. At the conclusion of the policy, 100% of the policy term has expired; thus, that point is located on the upper x-axis at the expiration date. The line connecting the effective and expiration points depicts the percentage of the policy term that has expired at each date.

4.3 Example Policies

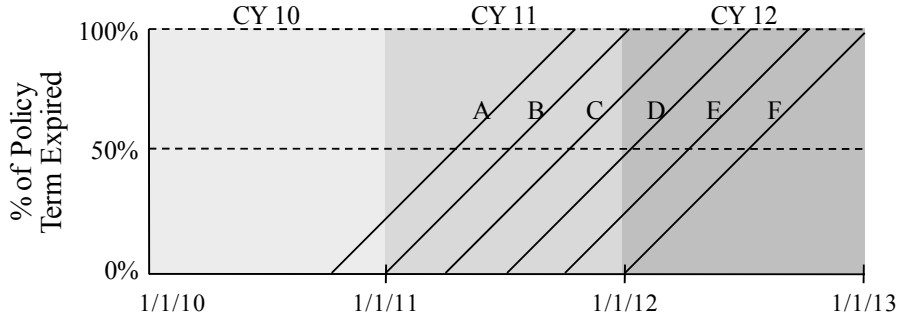


Calendar Year Aggregation and Accident Year Aggregation consider all exposures during the twelve-month calendar year without regard to the date of policy issuance; calendar and accident year exposures are generally the same[9] and the text will use the term calendar year exposure. At the end of the calendar year, all exposures are fixed. Since calendar year considers any transactions that occurred on or after the first day of the year, but on or before the last day of the year, calendar years are represented graphically as squares in the following picture.

[8] This assumes the policy is earned evenly throughout the policy period. Some products (e.g., warranties) do not earn evenly.

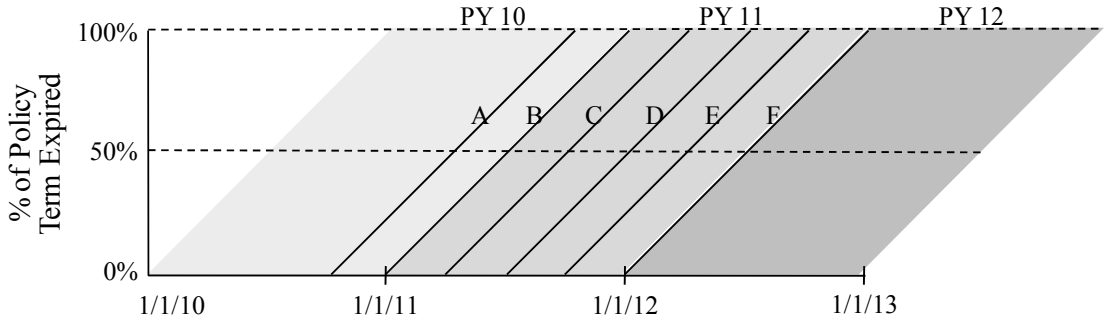
[9] There are some limited cases when the calendar and accident year exposures will not be equivalent. Policies that undergo audits will be discussed in the Premium Development section in the Premium Chapter.

4.4 Calendar Year Aggregation



Policy year aggregation, which is sometimes referred to as underwriting year, considers all exposures on policies with effective dates during the year. Thus, this is represented graphically using a parallelogram starting with a policy written on the first day of the policy year and ending with a policy written on the last day of the policy year:

4.5 Policy Year Aggregation

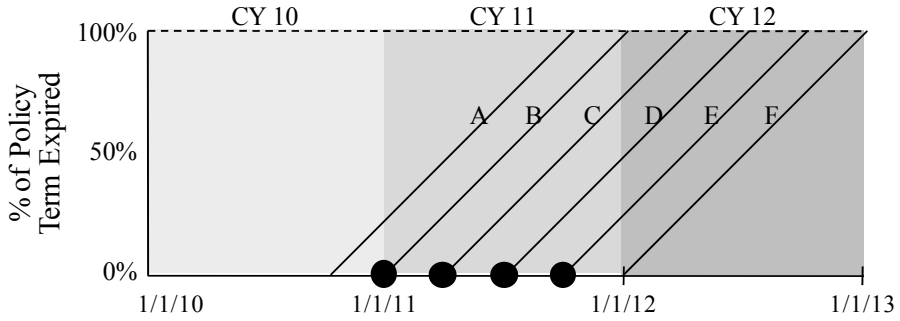


As demonstrated in the graph, the policy year takes significantly longer to close. For that reason, most ratemaking analysis focuses on calendar year exposures.

In addition to aggregating by calendar or policy year, exposures can be defined in four basic ways: written, earned, unearned, and in-force exposures.

Written exposures are the total exposures arising from policies issued (i.e., underwritten or, more informally, written) during a specified period of time, such as a calendar quarter or a calendar year. For example, the written exposure for Calendar Year 2011 is the sum of the exposures for all policies that had an effective date in 2011. As can be seen in Figure 4.6, Policies B, C, D and E all have effective dates (shown as large circles on the horizontal axis) in 2011, and their entire exposure contributes to Calendar Year 2011 written exposure. In contrast, Policies A and F have effective dates in years 2010 and 2012, respectively, and do not contribute to Calendar Year 2011 written exposure.

4.6 Calendar Year Written Exposures



The following table summarizes the distribution of written exposure to each calendar year:

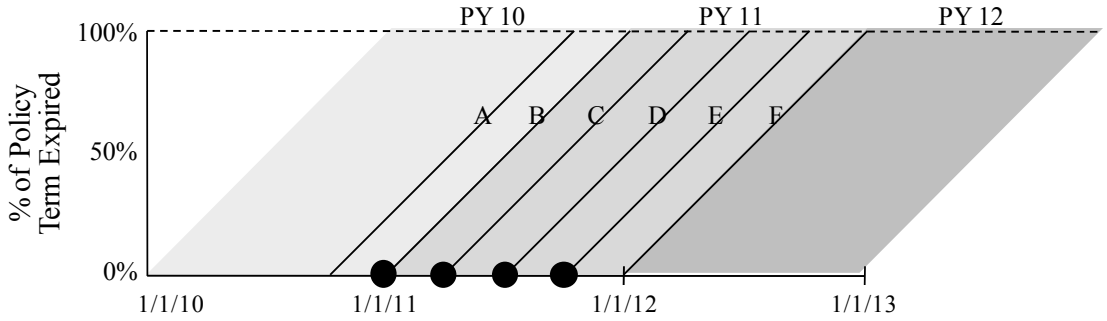
4.7 Calendar Year Written Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Written Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	09/30/11	1.00	1.00	0.00	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	0.00
D	07/01/11	06/30/12	1.00	0.00	1.00	0.00
E	10/01/11	09/30/12	1.00	0.00	1.00	0.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	1.00	4.00	1.00

Note each policy only contributes written exposure to a single calendar year in this example. If a policy cancels midterm, the policy will contribute written exposure to two different calendar years if the date of the cancellation is in a different calendar year than the original effective date. For example, if Policy D is cancelled on March 31, 2012 (i.e., after 75% of the policy has expired), then Policy D will contribute one written exposure to Calendar Year 2011 and -0.25 written exposure to Calendar Year 2012.

The following figure shows written exposure in the context of policy year aggregation.

4.8 Policy Year Written Exposure



The following table summarizes the distribution of written exposure to each policy year:

4.9 Policy Year Written Exposures a/o 12/31/12

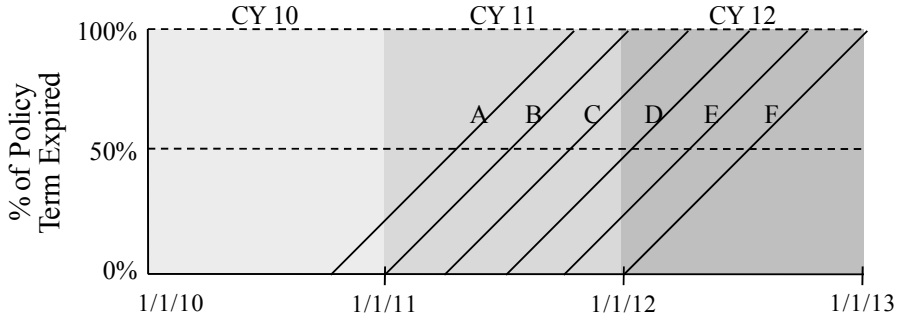
Policy	Effective Date	Expiration Date	Exposure	Written Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	09/30/11	1.00	1.00	0.00	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	0.00
D	07/01/11	06/30/12	1.00	0.00	1.00	0.00
E	10/01/11	09/30/12	1.00	0.00	1.00	0.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	1.00	4.00	1.00

Since policy year written exposure is aggregated by policy effective dates, the original written exposure and the written exposure due to the cancellation are all booked in the same policy year. As mentioned above, this contrasts with calendar year in which written exposure and cancellation exposure can apply to two different calendar years depending on when the cancellation occurs.

Earned exposures represent that portion of the written exposures for which coverage has already been provided as of a certain point in time. This example inherently assumes that the probability of a claim is evenly distributed throughout the year. For instance, if all policies were written on January 1 for a period of one year, the earned exposures as of May 31 would be 5/12 of the written exposures.

To better understand the difference between calendar and policy year earned exposure, first reconsider the calendar year picture:

4.10 Calendar Year Earned Exposure



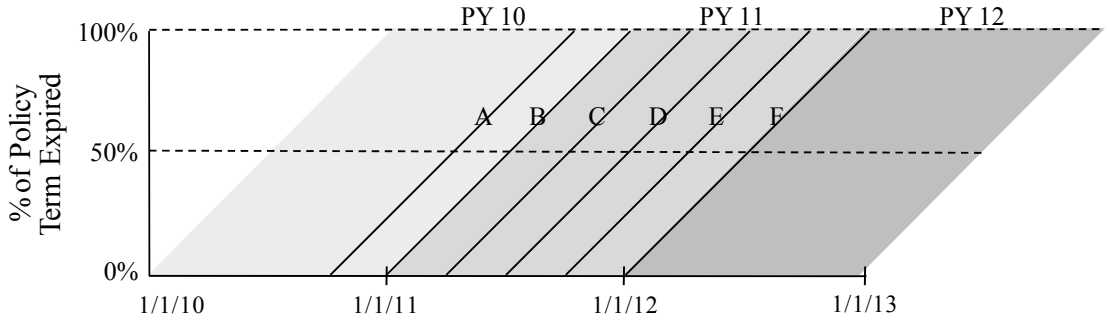
For Policy C in our example, 75% of the policy period is earned in 2011 and 25% of the policy period is earned in 2012; thus, Policy C contributes 0.75 (= 75% x 1.00) of earned exposure to Calendar Year 2011 and 0.25 earned exposure to Calendar Year 2012. The following chart summarizes the distribution of earned exposure to each calendar year:

4.11 Calendar Year Earned Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Earned Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	09/30/11	1.00	0.25	0.75	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	0.75	0.25
D	07/01/11	06/30/12	1.00	0.00	0.50	0.50
E	10/01/11	09/30/12	1.00	0.00	0.25	0.75
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	0.25	3.25	2.50

In contrast, the following picture relates to policy year earned exposure.

4.12 Policy Year Earned Exposure



As can be seen in the picture, all earned exposure is assigned to the year the policy was written and increases in relation to time. By the time the policy year is complete (24 months after the beginning of the policy year for annual policies), the policy year earned and written exposures are equivalent. Unlike calendar year earned exposure, exposure for one policy cannot be earned in two different policy years. The following table shows the policy year earned exposures for policy years 2010 through 2012 as of December 31, 2012.

4.13 Policy Year Earned Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Earned Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	09/30/11	1.00	1.00	0.00	0.00
B	01/01/11	12/31/11	1.00	0.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	0.00
D	07/01/11	06/30/12	1.00	0.00	1.00	0.00
E	10/01/11	09/30/12	1.00	0.00	1.00	0.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	1.00	4.00	1.00

The assumption of an even earning pattern does not hold true for lines such as warranty and those affected by seasonal fluctuations in writings (e.g., boat owners insurance). As such, actuaries analyzing these lines often specify other earning pattern assumptions based on historical experience.

Unearned exposures represent the portion of the written exposures for which coverage has not yet been provided as of that point in time. This applies to individual policies as well as groups of policies. For an

individual policy at a certain point in time, the following formula depicts the relationship between written, earned, and unearned exposures:

Written Exposures = Earned Exposures + Unearned Exposures.

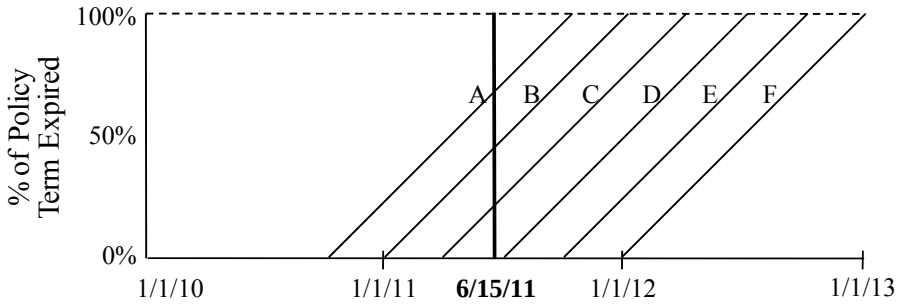
For groups of policies, the formula depends on the method of data aggregation. Policy year aggregation as of a certain point in time would follow the formula immediately above. Calendar year aggregation, however, would need to consider the unearned exposures at the beginning of the calendar year and at the end of the calendar year as follows:

CY Unearned Exposures = CY Written Exposures – CY Earned Exposures + Unearned Exposures as of the beginning of CY.

In-force exposures are the number of insured units that are exposed to having a claim at a given point in time. In other words, they represent the exposure to loss as a snapshot in time with no consideration for the duration of the exposure. The in-force exposure as of June 15, 2011, is the sum of insured units that have an inception date on or before June 15, 2011, and an expiration date after June 15, 2011. Not all insurance companies define "insured unit" the same way. Most companies define insured units to be the count of items exposed to loss at a given point in time. For example, if an automobile policy insures three cars, that one policy could contribute three in-force exposures at a given point in time. Alternatively, some companies may define insured unit in terms of the number of policies (the auto example above would have one in-force exposure under this definition) or the written exposures (in the auto example, there could be three in-force exposures if the term is annual, or 1.5 in-force exposures if the term is semi-annual).

A vertical line drawn at the valuation date will intersect the policies that are in-force on that date. As can be seen in Figure 4.14, Policies A, B, and C are all in effect on June 15, 2011, and each contributes to the in-force exposures as of that date.

4.14 In-Force Exposure



Assuming the "insured unit" refers to the number of houses exposed to loss, the following chart shows the in-force exposure for the example policies at three different valuation dates:

4.15 In-force Exposure by Date

Policy	Effective Date	Expiration Date	Number of Houses Insured	In-Force Exposure a/o 01/01/11	06/15/11	01/01/12
A	10/01/10	09/30/11	1.00	1.00	1.00	0.00
B	01/01/11	12/31/11	1.00	1.00	1.00	0.00
C	04/01/11	03/31/12	1.00	0.00	1.00	1.00
D	07/01/11	06/30/12	1.00	0.00	0.00	1.00
E	10/01/11	09/30/12	1.00	0.00	0.00	1.00
F	01/01/12	12/31/12	1.00	0.00	0.00	1.00
Total			6.00	2.00	3.00	4.00

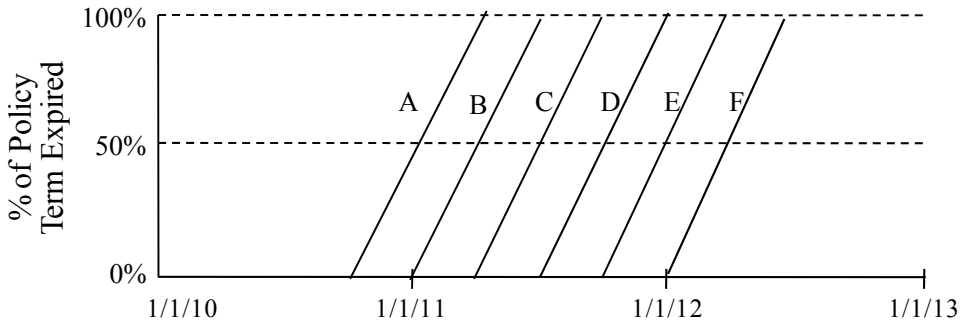
Policy Terms Other Than Annual

The preceding example illustrated the concepts of written, earned, unearned, and in-force exposures based on the assumption of annual policies. If the policy term is shorter or longer than a year, then the aggregation for each type of exposure will be calculated differently than outlined above. For example, if the policies are six-month policies, each policy would represent one-half of a written exposure. The picture and tables for calendar year and policy year aggregation of semi-annual policies are shown below.

4.16 Six-Month Policies

Policy	Effective Date	Expiration Date	Exposure
A	10/01/10	03/31/11	0.50
B	01/01/11	06/30/11	0.50
C	04/01/11	09/30/11	0.50
D	07/01/11	12/31/11	0.50
E	10/01/11	03/31/12	0.50
F	01/01/12	06/30/12	0.50

4.17 Example Policies



4.18 Calendar Year Written Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Written Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	03/31/11	0.50	0.50	0.00	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.50	0.00
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.50	2.00	0.50

4.19 Calendar Year Earned Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Earned Exposures CY 2010	CY 2011	CY 2012
A	10/01/10	03/31/11	0.50	0.25	0.25	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.25	0.25
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.25	2.00	0.75

4.20 Policy Year Written Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Written Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	03/31/11	0.50	0.50	0.00	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.50	0.00
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.50	2.00	0.50

4.21 Policy Year Earned Exposures a/o 12/31/12

Policy	Effective Date	Expiration Date	Exposure	Earned Exposures PY 2010	PY 2011	PY 2012
A	10/01/10	03/31/11	0.50	0.50	0.00	0.00
B	01/01/11	06/30/11	0.50	0.00	0.50	0.00
C	04/01/11	09/30/11	0.50	0.00	0.50	0.00
D	07/01/11	12/31/11	0.50	0.00	0.50	0.00
E	10/01/11	03/31/12	0.50	0.00	0.50	0.00
F	01/01/12	06/30/12	0.50	0.00	0.00	0.50
Total			3.00	0.50	2.00	0.50

Assuming insured units are defined as number of homes insured at a point in time, each semi-annual policy can contribute to one in-force exposure.

4.22 In-force Exposure by Date

Policy	Effective Date	Expiration Date	Number of Houses Insured	In-Force Exposure a/o 01/01/11	06/15/11	01/01/12
A	10/01/10	03/31/11	1.00	1.00	0.00	0.00
B	01/01/11	06/30/11	1.00	1.00	1.00	0.00
C	04/01/11	09/30/11	1.00	0.00	1.00	0.00
D	07/01/11	12/31/11	1.00	0.00	0.00	0.00
E	10/01/11	03/31/12	1.00	0.00	0.00	1.00
F	01/01/12	06/30/12	1.00	0.00	0.00	1.00
Total			6.00	2.00	2.00	2.00

Calculation of Blocks of Exposures

The preceding section illustrated how to convert the total exposure of individual policies into written, in-force, earned, and unearned exposures. Advances in computing power have enabled such techniques to be applied to individual policies. On the other hand, some companies may have policy information summarized on a monthly or quarterly basis and will need to calculate the exposures for the block of policies using this summarized data. In such a case, it is customary for the practitioner to treat all policies as if they were written on the mid-point of the period. For example, when data is summarized on a monthly basis, all policies are assumed to be written on the 15th of the month. This practice is often referred to as the "15th of the month" rule or the "24ths" method. This will be a good approximation as long as policies are written uniformly during each time period. If this approach is applied to longer periods (e.g., quarters or years), the assumption of uniform writings is less likely to be reasonable.

To clarify the application of this rule, consider the following example in which a company begins writing annual policies in 2010 and writes 240 exposures each month.

The in-force exposures represent the total exposures from active policies at a given point in time. While it is reasonable to assume that some of the 240 exposures written in July were in-force as of the first day of the month, the "15th of the month" rule assumes that none of the exposures from the July policies contribute to the in-force exposures as of July 1, 2010. This is because the rule assumes all the July policies are written on July 15th. Table 4.23 shows the in-force exposures as of July 1, 2010; January 1, 2010; and July 1, 2011, respectively.

4.23 Aggregate In-force Calculation

Written Month	Exposure	Assumed Effective Date	In-force Exposures a/o 07/01/10	01/01/11	07/01/11
Jan-10	240	01/15/10	240	240	0
Feb-10	240	02/15/10	240	240	0
Mar-10	240	03/15/10	240	240	0
Apr-10	240	04/15/10	240	240	0
May-10	240	05/15/10	240	240	0
Jun-10	240	06/15/10	240	240	0
Jul-10	240	07/15/10	0	240	240
Aug-10	240	08/15/10	0	240	240
Sep-10	240	09/15/10	0	240	240
Oct-10	240	10/15/10	0	240	240
Nov-10	240	11/15/10	0	240	240
Dec-10	240	12/15/10	0	240	240
Total	2,880		1,440	2,880	1,440