Some Distinctive Features of Steam Boiler Underwriting, and their Bearing upon the Formulation of Premium Rates.

BY

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It is nearly one hundred and fifty years since that great mechanical genius, James Watt, discovered and made practical application of the principles and power of expanding steam for the rotation of a shaft. His simple, crude steam boiler was the forerunner of the great steam power plants that have made possible our present vast manufacturing industries. To what extent the place of steam in the great world of industry is to be supplanted by modern power producers, such as all kinds of internal combustion engines, and electrical energy produced by water power, is open to conjecture. That electricity, which has already made its advent felt in the field of steam boiler underwriting, will ultimately become a very large factor, is probable. As yet, it has not produced any serious effect, and I refer to it here because the use of electricity for power purposes is constantly increasing—a fact that is presumably potent with many possibilities for the future of steam boiler underwriting.

A Brief History.

Steam boiler insurance originated in England. The increasing use of steam power brought with it a growing demand for more thorough and scientific inspections of steam boilers. As a result of a public meeting following a very disastrous boiler explosion in 1854, there was formed in the following year what may be considered the pioneer in this class of business. It is to-day known as "The Manchester Steam Users Association for the Prevention of Boiler Explosions and for the Attainment of Economy in the Application of Steam." No provision was made at that time for covering losses arising from explosions. It is possible that this omission gave rise to the founding in 1859 of the present Vulcan Boiler and General Insurance Company, which was the first company to

supplement the inspection service with an insurance policy. In 1864 the present National Boiler Insurance Company was organized, and has ever since continued under the same title. Two years later, in 1866, the Hartford Steam Boiler Inspection and Insurance Company (the first boiler company in this country) was founded.

This is, therefore, an appropriate time and place for your consideration of the subject of steam boiler underwriting, as both are associated with the fiftieth anniversary of its introduction into this country.

The Hartford company for a number of years wrote business in both the United States and Canada. In 1875 "The Canadian Steam Users Association" was formed, and in the following year it acquired the Canadian business of the Hartford company. It is interesting to note that exactly thirty years later, in 1906, the Hartford again acquired an interest in Canadian business through the Canadian Steam Users Association—the name having in the meantime been changed to that by which it is at present known, viz., The Boiler Inspection and Insurance Company of Canada. Although its policies are guaranteed by the financial resources of both companies, the personnel of the Canadian company, as also its assets, remains Canadian. For seventeen years the Hartford was the only company in the United States conducting this class of business. In 1883 a competitor, known as "The American Steam Boiler Insurance Company," was organized. After a brief and somewhat erratic career the American went out of business.

Although these two companies are the only ones that have been organized in this country to carry on the business of steam boiler underwriting solely and entirely, other insurance companies, particularly those engaged in liability underwriting, have added the writing of steam boiler policies to their other lines. At the present time there are thirteen companies engaged in this class of underwriting.

Great indeed have been the changes in both insurance coverage and practice since the Hartford company was founded in 1866. In those early days the insurance allowed under each policy was small, covering only specified amounts on each boiler, and on the machinery and buildings. Now the insurance under one blanket policy not only covers the property of the assured and the property of others for which the assured may be liable, but also the liability of the assured for loss of life and personal injuries.

Governed partly by a study of the meager experience of those early English boiler companies, though probably largely by their best judgment as to the relationship between the premiums and the cost of inspection, combined with the probable losses, the founders of the Hartford company decided upon yearly rates for premiums varying from 1 per cent. to 1½ per cent., with a minimum yearly premium of $30. To illustrate: A two-boiler plant having $750 insurance on each boiler, and $2,500 on machinery and buildings, or $4,000 in all, would at a pressure of eighty pounds have been written for a premium of 1 per cent., or $40 yearly. For certain increases in the pressure allowed, an increase would be made in the rate until 1½ per cent. was reached, producing a premium of $60. It was not until the early eighties that consideration of the pressure allowed ceased to be an important factor in determining the premium rate.

However logical such a percentage plan may have been when a specific amount of insurance was applicable to each boiler, the very unsatisfactory character of such a basis under the altered conditions of blanket coverage was long recognized. This plan of rate-making nevertheless held for many years, and it was not until the introduction of the Manual of Rates in 1913 that this percentage method was entirely discontinued. In the meantime, the percentages had dropped to an average of less than one per cent., and in some instances to less than one-half of one per cent.

Inspection Service.

The major portion of the premiums received by a boiler insurance company should be expended for expert mechanical services—in other words, for the care and inspection of the boilers covered under its policies. While this expenditure is of necessity heavy, it is justified by resulting benefits. Naturally these benefits accrue largely to the assured in the preservation and safe operation of his boilers and entire steam plant. Experience has also shown that the scientific examination and inspection of insured boilers produces a declining loss ratio. Conversely, any effort at a material saving in the inspection cost is fraught with danger of a large proportional increase in the loss ratio, to say nothing of the moral and social responsibility involved.

The following table taken from the *Locomotive* makes it clear that some very disastrous explosions have probably been prevented by the discovery and correction of dangerous defects:

Classification of Defects Discovered During the Year 1915.	Total Number of Defects Discovered.	Total Number of Dangerous Defects Discovered
Cases of sediment or loose scale	26,808	1,963
Cases of adhering scale	42,673	1,557
Cases of grooving	2,718	302
Cases of internal corrosion	17,843	867
Cases of external corrosion	10,872	932
Cases of defective bracing	973	246
Cases of defective staybolting	1,923	423
Settings defective	9,029	858
Fractured plates and heads	3,371	535
Burned plates	5,310	457
Laminated plates	354	40
Cases of defective riveting	1,516	274
Cases of leakage around tubes	10,670	1,475
Cases of defective tubes or flues	15,156	6,683
Cases of leakage at seams	5,060	420
Water gages defective	4,203	733
Blow-offs defective	5,185	1,616
Cases of low water	412	118
Safety-valves overloaded	1,489	453
Safety-valves defective	1,661	403
Pressure gages defective	7,958	1,050
Boilers without pressure gages	40	40
Miscellaneous defects	3,768	632
Totals for the year 1915	178,992	22,077
Totals for the year 1914	190,882	23,012
Totals for the year 1913	179,747	21,339
Totals for the year 1912	164,924	18,932
Totals for the year 1911	164,713	17,410
Totals for the year 1910	169,202	16,746
Totals for the year 1909	169,356	16,385
Totals for the year 1908	151,359	15,878
Totals for the year 1907	159,283	17,345
Totals for the year 1906	157,462	15,116
Total defects discovered during past decade	1,685,920	184,240

Of all boiler defects discovered during the past ten years, somewhat more than 10 per cent. were found to be of a dangerous character.

It is more to the advantage of a manufacturer to have an explosion prevented than to be reimbursed for a financial loss due to such a disaster. The assured thus receives dual protection under a

boiler policy: First, protection from preventable boiler accidents that would have caused more or less expensive losses; and second, protection from financial losses resulting from unprevented accidents.

This dual protection gives rise to the two principal elements of the premium rate: The element of inspection cost with its correlated features, and the element of the indemnity cost or the loss ratio. These two elements comprise what may be termed the net rate. To obtain the gross premium this net rate must necessarily receive a proper loading as in other lines of insurance. Such a loading would consist of the commission, the agency, and the general administration expenses.

I have purposely emphasized the dual protection secured under a steam boiler policy, as the distinctive features of steam boiler underwriting are attributable thereto.

Salaries and Expenses of Expert Mechanics.

An analysis shows that the cost of expert mechanical and inspection services comprises the largest single expense item. While the salaries of inspectors can be graded with reasonable uniformity, the travelling expenses will vary greatly with the territory covered. Indeed, when the results accomplished by inspectors travelling in the south and west are compared with the results accomplished in the same time in the thickly populated sections of the north, it is seen that even though the salaries be uniform the salary per boiler unit will vary. As the amount expended for expert mechanical services constitutes almost all of the inspection expenses, which in turn are about one-half of the entire premium income, equity requires that allowance be made in the premium rates for its unequal geographical distribution.

Quantitative Boiler Installation.

Another distinctive feature of this class of underwriting militating against the use of a uniform per boiler rate as a basis for determining premiums—a practice that in principle was at one time somewhat prevalent, and which was clearly erroneous—is the fact that in some localities there are large boiler installations, while in others there are only small and scattered units. More time being consumed, the cost per boiler is greater for inspections at plants

having the smaller installations. There are also additional expenses because of inspection visits to many plants instead of only one. These facts seem self-evident without further comment.

Relative Hazards in Different Kinds of Business.

We will now consider the relative boiler hazards in special kinds of business, and also the differing hazards and cost of inspection for certain types and makes of boilers.

The loss ratio for boilers of street railway and power companies has been found to be above the average. By the term "loss ratio," reference is made to the financial losses resulting from explosions, and not simply to the number of same. The relative *number* of explosions—accident ratio—among saw-mill boilers and kindred woodworking establishments is considerably greater than among boilers of street railway and power companies, and this is at least in part due to the relatively poor care and management they receive. The frequent and often great fluctuations in the load required in power plants of street railway companies is thought to be an important factor in the hazard element for boilers of these companies. The loss ratio for boilers in iron and steel works has also been found to considerably exceed the average. The average loss ratio for power boilers is much greater than for boilers used for heating purposes only; although there is a differing hazard for specific kinds of usage to which even heating boilers are put.

Relative Hazards and Inspection Cost for Different Types of Boilers.

That there is a difference in the element of hazard, and also in the cost of inspection, for different types of boilers is also a recognized fact. There are now in general use in this country two distinct types of boilers, viz.: The so-called "Water Tube" and "Fire Tube," with their respective variations of design. Time and its mechanical character forbid a discussion of the subject of the relative loss ratios for these two leading types of boilers. It may, however, be stated almost as a truism that at least the horse power per boiler unit, and also the cost of inspection per boiler unit, is greater among water tube boilers.

Statistics clearly prove that the accident and loss ratios for boilers of railroad locomotives have been excessively heavy. Frequently

these explosions have completely wrecked the locomotive. They have also caused many casualties. Damage, including that to tracks, cars and their contents, and to adjacent buildings, has amounted to hundreds of thousands of dollars. Many have been locomotives on the principal trunk lines of the country; and although the majority were pulling freight, some have been locomotives of passenger and express trains. These boilers are mostly uninsured. A few years ago the Interstate Commerce Commission promulgated its rulings to the effect that designing, construction, and inspection of these boilers must be subject to its approval. Statistics of the past year or two seem to indicate a favorable result of this ruling, as there is a noticeable decrease in the number of such explosions.

While considering types of boilers, reference should be made to the different types and kinds of vessels that carry steam, although they do not serve to generate it. Such for instance are rotaries, digesters, tanks, vulcanizers, and other insurable steam vessels. Some of these can be grouped and treated as forming a distinct class. Others must be treated as separate units. The premium must be computed independently for the group or for the unit, and must be based upon the peculiarities of the risk both with respect to the cost of inspecting and the relative hazard involved.

This theme of the types and kinds of boilers and steam vessels might well occupy an entire paper. There is time for no more than a mere intimation of its scope.

Normal Loss Hazard.

Observation seems clearly to indicate that the relative number of casualties in the United States from various causes is greater than in England. Such statistics as are available show that the boiler casualties are also greater. It is quite generally accepted that one of the underlying causes for this difference is to be found in a national characteristic: The desire to achieve the greatest results in the shortest space of time possible. This national spirit of "hustle" must of necessity enter into all the processes of construction, installation, and operation of boilers, and therefore have a cumulative effect tending to result ultimately in accidents and explosions.

Another reason for the difference in the relative number of casualties in the two countries disclosed by both observation and statistics for the past few decades, can be traced to the fact that this period has been one of unparalleled expansion, change, and growth

in the American industrial world; while on the other hand, in England the laws and the general conditions of labor have been much more stable.

Through the efforts of liability companies, the enactment of compensation laws and the growing philanthropic spirit on the part of employers, industrial conditions are rapidly changing for the better in this country. Therefore it requires no prophet to discern that comparative statistics for the next few decades, or even for the next decade, will tell a different story. As studied efforts to safeguard the worker become universal in America, and the worker becomes accustomed to exercising greater care himself, there should come about a natural tendency on the part of both employer and employee to be prudent and cautious. Such a tendency would become apparent in all lines of business, developing into a national habit. The result of this changing process should be a reduction in the number of casualties of all kinds. The specific result upon the normal loss hazard in steam boiler underwriting cannot be other than favorable.

The Catastrophe Hazard.

There yet remains to be considered the catastrophe hazard. In a sense this hazard is not peculiar to steam boiler underwriting. It does, however, differ in both degree and kind. It differs in degree in that it is not as great as in some other lines, as, for instance, in accident and fire insurance. Although it is incomparably less than in fire insurance, it is essential to note that the aggregate annual premiums are also incomparably less.

Any consideration of the catastrophe hazard brings before us the subject of the varying insurance limits per boiler unit—that is to say, the amount of insurance at stake on each boiler or battery of boilers. Until within a few years a limit of about $5,000 was considered the proper average amount of insurance per boiler unit. As the financial resources of the boiler companies increased, attention was given to the fact that the catastrophe hazard was in no measure even approached by such a small limit.

The modern practice of installing large boiler units to reduce operating cost has become an important feature. Where formerly two boilers of 200 horse power or even three of 125 horse power were considered essential, now one large boiler of from 400 to 500 horse power may be installed. Indeed, instances are not wanting of over 2,000 horse power for a single unit. A premium based

upon $5,000 of insurance per boiler unit would, in a three-boiler battery, when replaced by one 400 or 500 horse power boiler, be reduced proportionately; thus yielding a cash premium only 33⅓ per cent. as great as for the three-boiler unit, and with a probably increased hazard. The inequity of this situation is obvious.

Statistics and experience have also shown that accidents have occurred entailing a property loss to the assured over and above his policy coverage because of his carrying insufficient insurance. The passage of liability and compensation laws by the several states already alluded to has added to the possibility of heavy compensation and liability claims in the event of an explosion causing loss of life or personal injuries. These and other considerations have during recent years led to a much larger coverage per boiler unit. A total coverage under one policy of several hundred thousand dollars is not now considered unusual. This tendency is undoubtedly wise, and decidedly in the interest of the assured. It has also given rise increasingly to the reinsurance of surplus lines, and has brought to the forefront the necessity for equitable rates for such reinsurance.

In considering the catastrophe hazard, it may be of interest to recall some catastrophes. One such occurred at Milwaukee, Wis., in 1909, when three boilers exploded, entailing a loss of approximately $125,000. It was only four years prior to that that one of the worst calamities in the history of boiler underwriting occurred at Brockton, Mass. As a result of the explosion and ensuing fire 175 persons were injured, of whom 58 died. The estimated property loss was about $250,000. Two years prior to that there occurred a disastrous explosion at the plant of a traction company in St. Louis, when seven water tube boilers exploded simultaneously. Nine years earlier, in 1894, there occurred a remarkable calamity at Shamokin, Pa., when thirty-six boilers exploded at the same time.

Should a calamity occur under a modern blanket policy with its very large insurance coverage applicable to a single accident, the loss ratio might easily exceed all previous experience.

A boiler plant is latent with possibilities of a calamity. The direction of the explosion and the human lives in the path of the ruptured boiler may mean more in the measure of the calamity than the value of the property on which the boiler is located. Ex-

ploded boilers have travelled half a mile and more, and several hundred feet is no unusual occurrence.

From the very nature of things it is impossible to gauge either the time or financial results of the catastrophe hazard. As well might one presume to gauge the recurrence and probable results of an earthquake by the times and results of similar disasters in the past. Surely the wisest course is to provide the best possible inspection service as a safeguard against it.

A Premium Formula.

Possibly the most satisfactory method thus far devised for calculating basic premiums for this class of underwriting may be expressed algebraically as follows:

$$\{N(25) + L\} + \{2M + N(.10M)\} = G/P.$$

L = District apportionment.
M = An indemnity, or loss unit of $1,000.
N = A per boiler unit.
G/P = Gross premium.

The 25 is used to represent a minimum per unit charge for inspection service, and a somewhat arbitrary but just loading for commission, agency and general administration expenses, therefore, $\{N(25) + L\}$ determines that portion of the premium essential for the inspection service and the expense loading, after making provision, by the introduction of the symbol "L," for the unequal geographical distribution of the inspection expense heretofore noted.

The $2M$ represents a fixed charge of $2 per each thousand of insurance, irrespective of the number of boilers involved; as increasing the number of boilers covered really increases the hazard to some extent the next symbol, namely $N(.10M)$ is introduced. Although this is a level charge of 10 cents per each thousand of insurance, it is believed to be equitable in that it varies with the per unit hazard, and it in part makes provision for that very illusive thing called the "catastrophe hazard" also. In its entirety, namely $\{2M + N(.10M)\}$ this part of the formula provides for indemnity, that is to say for losses solely.

Quantitative boiler installation may be considered as automatically adjusted by the application of the formula to the special conditions

of each plant. Expressed in its simplest form the formula would read as follows:

$$2M + N\left(\frac{}{10} + 25\right) + L = G/P.$$

Notable indeed has been the change and progress from the old pioneer method of determining yearly premiums on the basis of a percentage of the limited amount of insurance at that time allowed. There is reason to expect that with the increase of valuable data and the enlargement of the field of experience, rates and practices will approach more and more to that goal of scientific accuracy and justice desired by every progressive steam boiler underwriter.