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POLICY NOTIFICATION

Pressure Relief Valve Rating for Section IV Boilers

The previous Circular Letter was issued on May 2, 2000.

The Section IV Subcommittee has not changed the criteria; therefore, this bulletin is still pertinent.

There has been considerable discussion within the Section IV Subcommittee regarding keeping or amending Table HG-400.1.

The appended article by Bob Ferrell of National Board of Boiler and Pressure Vessel Inspectors sheds some light on present and proposed Code requirements. This article should prove to be useful.

When changes are made, we will update this Policy Notification.

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Code Rating of Boiler Capacity

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There has been a lot of discussion recently concerning the use of boiler heating surface to determine a minimum capacity requirement for safety or safety relief valves. It has been stated that application of paragraphs HG400.1, HG-400.2, HG-400.3 and the referenced table HG-400.1 of Section IV may not be accurate for some boiler designs. Analysis indicates that some boiler designs of relatively small commercial sizes may have a higher output capacity than calculated using the factors in table HG400.1 when equipped with specific type burners. However, for most commonly manufactured boiler systems, use of the table appears sufficient to determine the minimum relief capacity needed.

THE PURPOSE OF THE TABLE

It is fully understood that pressure-relieving devices will never be rated to the exact numerical value of the boiler output. The Code provides an objective, uniform, minimum method to determine pressure relief capacity. The calculation of specific boiler capacities is not simple, as many factors must be considered. The purpose, regarding capacity, of paragraphs HG-400 of Section IV is to provide a minimum capacity of the pressure relief device(s). It is not to determine a specific boiler output. In the past organizations such as the Steel Boiler Institute and the American Boiler Manufacturers Association provided boiler rating charts based on common standards. However, those charts are no longer being published.

If the table is removed from the code, what standard is to be used by owners, inspectors and manufacturers to determine a minimum requirement? Do we revert to the late 1800's and start all over again with no standard? Or is the methodology to calculate specific boiler capacities going to be added to the code?

HISTORY

In the late 1800's, as steam boilers were coming of age, there were no industry standards for ratings. Every boiler was designed and rated as an individual unit, which was determined by the manufacturer, users or an accumulation test. The industry did not have a recognized standard to rate boilers until 1876. In 1876 the Committee of Judges at the Centennial Exhibition established the standard of "Boiler Horsepower" which was defined as the evaporation of 30 pounds of water from feed-water at 100 degrees Fahr. to 70 pounds steam pressure. This is equivalent to the evaporation of 34.5 pounds of water from 212 degrees Fahr. at atmospheric pressure. The American Society of Mechanical Engineers adopted this definition as a standard in 1889. Depending upon your source of information, the quantity of 's/ Hour in a Boiler Horsepower is between 33,327 and 33,520. The defining of boiler horsepower still did not address calculating boiler capacity. Some boilers were being rated by using grate surface while others were using actual heating surface. R.C. Carpenter wrote, ¹ "It is the general practice to

¹ Heating and Ventilating Buildings; R.C. Carpenter, M.S., C.E.M.M.E.; John Wiley and Sons; 1903 fourth edition

consider 10 square feet of heating surface in water-tube boilers or 15 square feet in plain tubular boilers as equivalent to one horsepower”. He continues “The actual power of the boiler depends more upon the method and management of the fires than upon the size. Either of the above classes of boilers can be made to develop under favorable circumstances from two to three times the capacity for which they are rated. This statement is significant because its rationale is still true today. He was noting that there is more than one factor affecting capacity.

Prior to 1927,² Section IV, Low Pressure Heating Boilers was changed to base minimum relieving capacity on the grate area from using heat transfer surface. In 1941 the code again changed to determine the needed capacity of the safety valves or water relief valves by dividing the maximum output at the boiler nozzle in 's per hour obtained from the fuel by 1000 or multiplying the boiler heating surface by five. In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules. The code was and is still ambiguous concerning the determination of this greater relieving capacity.

These requirements remained unchanged until the 1965 Edition of Section IV, 1966 addenda. The minimum valve capacity was still determined by the output at the boiler nozzle with the additional option of determining capacity on the basis of pounds of steam per hour per square foot of boiler heating surface as given by the following Table. As can be seen, the type of fuel and method of firing is denoted in the table as well as whether the heating surface is of a firetube or watertube boiler.

Minimum Pounds of Steam Per Hour Per Sq. Ft. of Surface		
Boiler Heating Surface	Firetube Boilers	Watertube Boilers
Hand-fired	5	6
Stoker-fired	7	8
Oil, gas, or pulverized fuel-fired	8	10
Note 1 When a boiler is fired only by a gas having a heating value not in excess of 200 per cu. ft. The minimum safety valve or safety relief valve relieving capacity may be based on the values given for hand-fired boilers above.		

² History of the ASME Boiler Code: A.M. Greene Jr.; American Society of Mechanical Engineers International, 1953 second printing

Note 2 The minimum safety valve or safety relief valve relieving capacity for electric boilers shall be 3.5 pounds per hour per kilowatt input. In 1969 the code revised the Table to separate boiler heating surfaces from waterwall heating surfaces with differing factors and identified it as Table HG-400.1. It hasn't been revised since. The statement, 'In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules' is still made in HG-400.1(d).

Reviewing this information, it would be safe to say that for the last 100 years heating surface has always played a part in determining what is used as a minimum requirement for relief/safety-relief valve capacity. However, actual firing rate has continually been noted as a potentially higher capacity requirement.

It is true that the table has been slow to respond to combustion technology improvements. Some boilers installed with state of the art boiler/burner combinations of today are not considered in the present table. Some of the factors in the table appear too low and some too high

REVISION REQUIRED

In the past twenty years or so, attempts to improve the fuel to steam efficiency in boilers have led to new designs in boiler tubing and burner design. An example is a low volume copper /finned watertube boiler. At least one manufacturer has shown that the present table can over size a valve by as much as 300%. Creating a factor specific to copper finned watertube boilers would provide relief from the existing factors. Several manufacturers have been contacted and they feel that a factor of six(6)times the square foot heating surface for a gas or oil fired burner would more accurately provide a minimum capacity for these units.

In the current code, extended heating surface is treated as water-wetted surface. A more realistic allowance for extended surfaces could also be addressed in HG 403. For instance the fin efficiency for copper fins can vary from 80 to 100% and for carbon steel it can be from 50 to 90%. This viewpoint is noted in V. Ganapathy's article concerning heat transfer surface,³ Use of finned tubes also distorts the picture significantly. With finned tubes, the surface areas can be 100 to 200 percent higher while transferring the same.

The following is an example of the use of table HG400.1 with the proposed additional factor of 6 for copper finned or extended surface watertube boilers compared to the existing factor of 10 for gas and oil firing.

The unit will be gas fired rated at 2,000,000 /hr with a heat transfer surface including the finned area of 340 square feet. The relief valve set pressure will be 160 psig (water). The valves used will be rated for steam.

³What you should know about boilers and performance, V. Ganapathy, October 1997, Plant Services

<u>PRESENT FACTOR</u>	<u>PROPOSED FACTOR</u>
340 sq. ft. X 10 = 3,400 #/hr	340 sq. ft. X 6 = 2,040 #/hr
Requires a typical 1" valve rated 5353 #/hr	Requires a typical 3/4" valve rated 3307#/hr

The results are more closely related to actual boiler output capacity in accordance with manufacturer comments. The table factors are provided as a fail-safe minimum. By addressing the impact on copper watertube boilers and extended surfaces with a more realistic industry-supported factor we can ensure the results assist in maintaining a fail-safe minimum.

Another condition which has raised questions regarding the use of Table HG 400.1 is the calculation of boilers/burners firing with a input greater than 7000 s per square foot of heating surface (industry norm). These units can fire as high as 26,500 s per square foot of heating surface. A common use of this high input unit is sold in Ohio and referred to as an OHIO Special. This unit is designed to produce a higher output using less than 359 square feet of heating surface. These units are an exception in the industry and cover a small range of sizes from 4,200,000 input to 11,960,000 input. For this type of over firing condition HG 400.1(d) states "In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules" which does allow for engineering expertise to deliberately exceed the industry norm.

Regarding units exceeding industry norms, the units must comply with HG 400.1(d) and two notes should be added to the table.

Proposed addition to GENERAL NOTES:

(d) For firetube boiler units exceeding 8000 /sq ft (total fuel input divided by total heating surface from HG 403), the factor from the table will be increased by 1 for every 1000 /sq ft above 8000. For units with less than 7000 / sq ft, the factor from the table will be decreased by 1 for every 1000 /sq ft below 7000.

(e) For watertube boiler units exceeding 16000 /sq ft (total fuel input divided by the total heating surface from HG 403), the factor from the table will be increased by 1 for every 1000 /sq ft above 16000. For units with less than 15000 /sq ft, the factor in the table will be decreased by 1 for every 1000 /sq ft below 15000.

The following tabulation provides examples of using note (d) and (e).

An example of the use of Note (d)

The first is shown an Ohio Special firetube boiler with 359 sq. ft. of heating surface fired at various input rates and calculated for minimum valve capacities.

OLD FACTOR+ADJUSTMENT			
<u>INPUT</u>	<u>/SQ FT</u>	<u>TIMES HEAT. SURFACE (359 sq. ft)</u>	<u>MIN. VALVE CAP</u>
4,200,000	11,699	8+3	3949 #/HR
5,236,000	14,585	8+6	5026#/HR
6,272,000	17,470	8+9	6103#/HR
7,350,000	20,473	8+12	7180#/HR
8,372,000	23,320	8+15	8257#/HR
9,450,000	26,323	8+18	9334#/HR

An example of the use of note (e).

This second portion shows a small watertube boiler fired with a Hi-efficiency burner.

1,500,00	23,809	16+7	(63 SQ FT HS)	1449#/HR
2,000,00	31,746	16+15	A	1953#/HR
2,500,00	31,250	16+15	(80 SQ FT HS)	2480#/HR
3,000,00	37,500	16+21	A	2960#/HR

As can be seen, the present table factors provide a basis for adjustment using a consistent method of compensation for the variation in input. Essentially, by adjusting the present factor by the same rate of input increase or decrease per square foot of heating surface, the table comes up with a capacity very close to the requirements of HG 400.1 (d) The minimum relieving valve capacity in pounds per hour shall be the greater of that determined by dividing the maximum output at the nozzle obtained by the firing of any fuel for which the unit is installed by 1000.

The examples show that there is a correlation between the table factors and the industry norm (or average) heat transfer rate/square foot. They also show that rates different from the industry norm can be compensated for using the table and a consistent correction method.

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