

REDEFINING NEEDED FIRE FLOW

Edward Burns, Assistant Chief (Ret.)
Los Angeles City Fire Department

Burton W. Phelps, Deputy Chief (Ret.)
Anne Arundel County, MD

This article enhances the information provided by Mr. John D. Wiseman, Jr. on *Defining Needed Fire Flow* in the December 1993 issue of *The Voice*. While most of the information in the Wiseman article is accurate, there are specific issues that make the graph and conclusions inaccurate.

The Iowa Formula

This formula was developed by Mr. Keith Royer during World War II at the United States Coast Guard Yard in Baltimore, MD. Mr. Royer was working with Chief Lloyd Layman to develop firefighting techniques for shipboard firefighting for the U.S. Navy. Mr. Royer, after the war, continually proved the accuracy of the formula during his 40-plus years of service at the University of Iowa Fire Extension Services.

To understand fully the concept of $(L \times W \times H) / 100$; one must explain the operational concepts and how limited water must be delivered to achieve fire control in a short period of time. The concepts are:

- Keeping oxygen from the fire to stabilize and limit BTU production.
- Determine the needed fire flow based on the volume of space in the largest fire area. The water required for the largest space in a structure will be sufficient to handle any of the smaller areas.
- When the space is involved in fire:
 - Do not vent the space that is burning. The formula is based on absorbing the BTUs being produced by converting water to steam thereby providing an inert, cool atmosphere.
 - Supply the needed fire flow to the incident scene before starting fire attack.
 - Using multiple small lines, choose exterior positions that will allow nozzle patterns to completely cover the involved space.
 - Make small openings for the nozzles, e.g., break a small pane of glass or slightly open a door to keep oxygen input to a minimum.
 - Nozzles are typically placed on a 30 degree fog pattern for reach.
 - On a signal, open all nozzles simultaneously for approximately 30 seconds. Then close the nozzles.
 - Vent the space and enter for final extinguishment.

Mr. Royer proved the accuracy of the formula many times over the past 50 years. And, we all agree that given the operational concepts it does work well.

Figure #1 graphically displays the concept of operation.

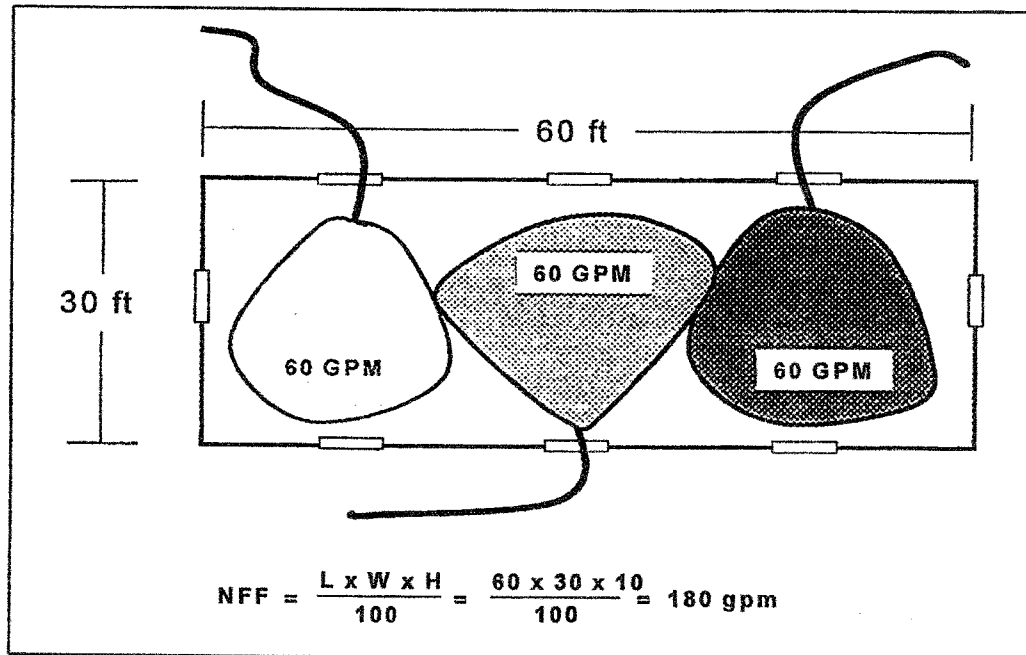


Figure #1

The critical questions that must be answered are:

How many of you fight structure fires this way?

- Do you leave the structure "buttoned-up" until the total Needed Fire Flow is on the fireground?
- Do you use multiple hoselines to deliver a total of 180 GPM and choose two or more distribution points to obtain full, simultaneous coverage of the fire area from the exterior?

If your department fights structure fires this way, then the Iowa formula is made just for you. The conclusion would be to continue to use it. However, for success with the limited fire flow, you must also use the delivery concepts. Any significant openings in the structure, horizontal or vertical, will let steam escape and oxygen to enter thereby increasing BTU production, the fire flow and time required to darken-down the fire.

In addition, a fire area over 10,000 square feet, e.g., 100' x 100' or interior wall configuration, affects our ability to get complete coverage simultaneously. Most fog nozzles on 1 3/4" lines have an effective 30 degree fog stream reach of less than 50 feet. Many of us do not have the number of firefighters required to distribute 1,000 GPM to multiple openings through four to six hoselines just after arrival at the scene. Thereby, the 1,000 GPM cap on the effectiveness of the Iowa formula is reasonable.

NFA'S Field Formula

In early courses, circa 1979-84, the National Fire Academy used both the ISO Fire Flow Formula and a modification of the Iowa Formula. When the *Preparing for Incident Command (PIC)* course was rewritten, the new NFA Formula was developed.

$$\text{NFF} = \frac{L \times W}{3} \times \% \text{ Involvement}$$

PREINCIDENT PREPARATION

The full, or prefire planning, formula is $NFF = \frac{(L \times W + \text{Exposure Charge})}{3} \times \% \text{ Involvement}$

The course developers, all experienced incident scene commanders, discussed the practicality of the Iowa formula for normal operations. Normal operations include actions, such as:

- Performing primary search and rescue before people die in heavy smoke conditions. In this instance, often before total extinguishment water is available on-scene, engine company personnel are entering the building with hoselines to push, or keep, the fire away from possible victims. Truck companies are doing horizontal and maybe vertical ventilation to support the primary search effort. The structure's ability to contain steam has been violated. Extinguishment will now take greater fire flows.
- Fire attack is started by the first arriving engine company and is reinforced with additional fire attack and back-up lines as resources arrive on-scene. Personnel are venting as they go and the roof may be ventilated to remove the smoke and toxic gases to the outside.

Yes, the NFA Formula provides more water than is needed for extinguishment then when we leave the building buttoned-up. However, if we really take multiple 1-1/2" or 1-3/4" hoselines into a building for attack and back-up, then we must supply the water that will allow all of them to flow simultaneously, to do otherwise is courting disaster. The NFA Formula provides a fire flow safety factor when compared to the Iowa Formula. This is very desirable when crews are operating on the interior.

A study of the American Fire Service will show that better than 99% of us do aggressive interior fire attack as discussed above. We are taught not to attack a fire from a window or door position that will push the fire through the structure. We are taught to go inside and push the fire from the unburned back to the burned and out of the structure.

The PIC course developers designed several fire scene plot/floor plans showing building size and openings with varying percents of involvement. These were duplicated during one of the development meetings and distributed to a number of the NFA students who were on campus. Each student was directed to show hoseline placement and size on the plot/floor plans indicating how their department would control the fire from a hoseline perspective.

These plot/floor plans were collected and analyzed. For each scenario, when the floor area was divided by the needed fire flows indicated by the students, the result averaged approximately 3. This resulted in the linear equation $NFF = (L \times W) / 3$.

What were the parameters:

- All the fire scenarios were designed to be aggressive interior firefighting operations. Fire involvement percentages above 50% are not normally interior fire attack situations.
- All operations would be as they are in the real structural firefighting world. We start with a single interior attack line and increase the number of lines as needed and as resources arrive on-scene.
- The necessary primary search and ventilation would be achieved simultaneously with fire flow operations.

The NFA courses are very clear in stating that (1) the formula is designed for use in aggressive interior fire operations, (2) the formula becomes increasingly inaccurate above 50% involvement or when resultant flows are above 1,000 GPM, (3) it is not designed for defensive, masterstream operations, and (4) there are other variables that affect needed fire flow. The formula is based on the largest fire area in a structure, as is in the Iowa Formula.

PREINCIDENT PREPARATION

Taking into account the operational concepts and parameters, the NFA Formula is more accurate than the other two for how the American Fire Service delivers water to a real-world structure fire.

Prove it to yourself.

1. Think of a 50'x60', 1-story, small commercial. The structure is 50% involved.
2. Approximating scale, draw the building on a piece of paper showing a front and back door and some side windows. Example Figure #2:

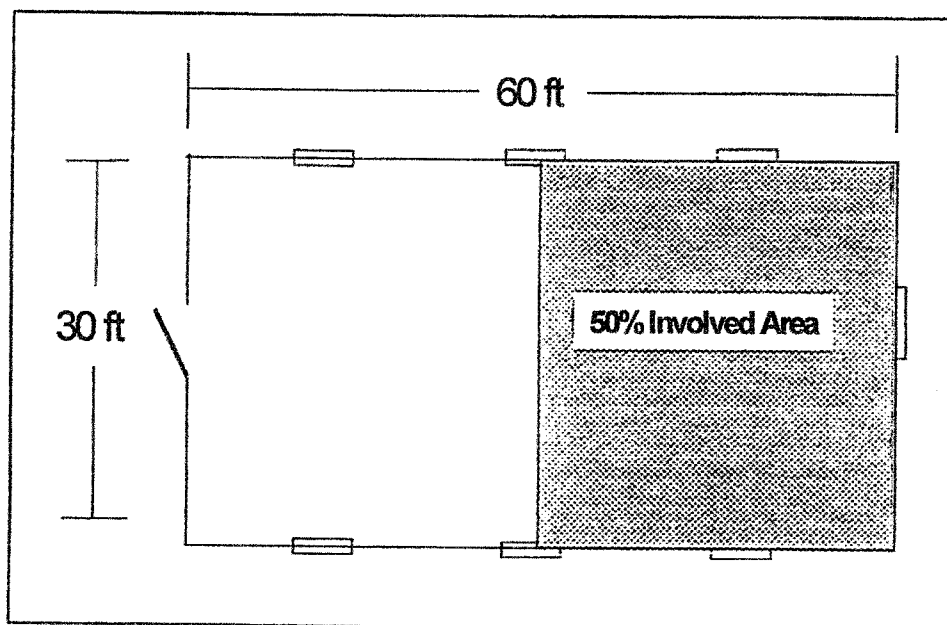


Figure #2

3. Before calculating a fire flow using any formula, determine how many and what size hoselines you would order pulled and charged to attack the fire. The fire just flashed-over and structural integrity is good at this time.
4. Convert the number and size of lines to GPM and add to determine the total fire flow.
5. Now, using both the Iowa Formula and the NFA Formula calculate the needed fire flow.

Remember, for this example, the percentage of involvement was 50%. Half the involved area translates to half the calculated fire flow from either formula. Which one is closer to the flow that would supply the number of hoselines chosen.

6. Do several more the same way for other fire areas in commercial establishments in your community.

This analysis makes neither formula wrong. It simply states that the formula concepts and parameters must be known to make the correct choice. For our example above, the Iowa formula yields 90 GPM (e.g., 30 GPM through three different nozzles to provide fire area coverage) and the NFA formula yields 300 GPM (two 1-3/4 inch lines or three 1-1/2 inch lines).

The Iowa Formula for our example is correct if you leave the building "buttoned-up", did no search, and applied the water simultaneously from multiple exterior openings that would cover the fire area.

However, if you are firefighting the conventional way, the NFA formula is closer to your needs.

In addition, based on the article "Critical Flow Rate" by C. Bruce Edwards, Fire Engineering, September 1992, delivering water at a rate greater than the formula minimums extinguishes a fire in much less time. The NFA Formula, by calculating for Fire Department inefficiency, allows greater flow rates and reduced extinguishment time relative to the Iowa Formula.

Graph Results

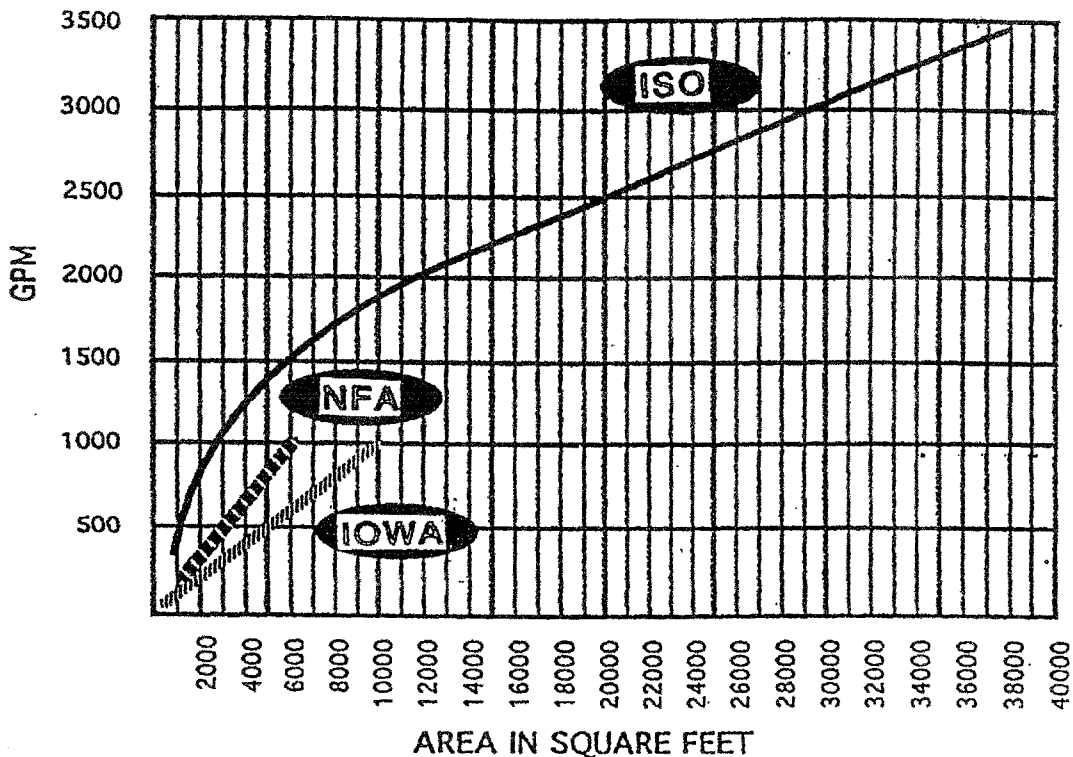
Using Mr. Wiseman's graphical display. We find that the ISO Formula curve remains the same, as does the Iowa Formula curve.

Keeping in mind that the ISO and Iowa Formula graphs are not limited by percent of fire involvement.

The NFA Formula curve is changed from the Wiseman example due to the parameter that specifies not greater than a 50% involvement in the fire area. In agreement with Mr. Wiseman, we believe that aggressive interior fire attack has a probable upper limit of 1,000 GPM.

In the graph for the NFA formula, we have plotted the flow based on the maximum 50% involvement for a 6,000 square foot building. However, when a building of 12,000 square feet with 25% involvement is used, the formula will provide a different curve when carried to the maximum of 1,000 GPM. Therefore, the NFA formula may produce an endless number of curves when the two variables percent involvement and/or square foot area are changed.

It is believed that the NFA Formula does provide a reasonable fire flow recommendation for heavy stream attacks when the formula answer is above 1,000 GPM. This belief must be qualified by stating "before too much vertical and horizontal integrity are lost to burn through."



Summary

All three fire flow formulas are correct when used within their individual design parameters.

The ISO Formula was designed for setting insurance rates and rating fire departments. If you are in that business you should use it. It is far too complex to be used at an incident scene and it obviously provides for the greatest fire flows. After all, it is an insurance industry formula.

The Iowa formula was designed for calculating fire flows needed in compartmentalized fires, such as on ships. While the application is transferable to structure fires, it is not the way most of the American Fire Service attacks structure fires. If you attack structure fires by the concepts of the Iowa for as described earlier, then it is the formula you should use.

The NFA formula was formulated from the experience of the structural incident scene commander. The NFA Formula provides for flows that are based on how the far majority of the Fire Service attack structure fires.

We can conclude that the best all-around formula for the structural fire officer ordering an aggressive interior attack is the NFA Formula. As with all fire flow formulas, the resultant flows may have to be modified based on experience, common sense, and good judgment.