PUBLIC HEALTH ASPECTS OF CROSS CONNECTIONS AND DUAL WATER SUPPLIES


New York State Department of Health, Albany, N. Y.

A CROSS CONNECTION may be defined as a physical arrangement whereby a public water supply system is connected with another water supply system, either public or private, in such a manner that a flow of water into the public water supply system from such other water supply system is possible. The various communities of New York State have spent vast sums of money to secure for the people an adequate supply of water of a satisfactory character. Great care is taken constantly to maintain the sanitary quality of this water before its entrance into the public mains, and yet the majority of our cities permit cross connections between the public water supply and independent private supplies of known impurity. Frequently the definite presence or location of these cross connections is not known to the local water supply authorities.

It is the present practice of the fire underwriters to require for their large commercial and industrial risks an independent water supply furnished either by direct pressure through private fire pumps or through fire pumps to elevated tanks. The purpose of the auxiliary supply is to give an independent source of supply in case of failure of the public supply or to supplement the capacity or pressure of the latter supply. Furthermore many industrial concerns, for the purpose of economy, use private supplies for manufacturing purposes.

To the interconnection of these auxiliary supplies with the public water supply, either directly or through gate valves and check valves, have been traced numerous epidemics of typhoid and other enteric diseases either within the factory itself or in the municipality whose water supply has thus become contaminated. Inasmuch as it is generally possible for the pressure of the private supply to be or to become greater than the pressure of the public supply, the potential danger of pollution of the public supply is always present. Whereas the pressure of the public supply may be relatively high, it is possible at times of unusually large drafts on the supply or in case of breaks or repairs to the mains that the pressure may be materially reduced or even become zero.

That such conditions constitute an actual menace to public health is shown in Table I which gives outbreaks of typhoid fever due to cross connections. Although this list is not complete, it shows numerous outbreaks of typhoid fever, resulting in thousands of cases of typhoid and more than 100 recorded deaths since 1903. All of these outbreaks were definitely traced to cross connections between public water supplies and polluted private supplies. There were 9 outbreaks in New York State, in 2 of which—Herkimer and Seneca Falls—there were 155 and 102 cases of typhoid respectively.

The question of cross connections has become a matter of increasing interest and importance during the past few years as is evidenced by the space given this subject in the medical and engi-
TABLE I

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Typhoid Cases</th>
<th>Deaths</th>
<th>Other Enteric Diseases or Disturbances</th>
<th>Remarks</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circleville, O.</td>
<td>1914</td>
<td>43</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following excerpts are from these reports:


Greater safety is unquestionably attained by providing two well-constructed check valves where dependence was formerly placed upon a single valve of but ordinary construction. Let it be said here that too much emphasis cannot be laid on the construction of these valves.

It is impossible to state how much more security two high class check valves afford than is afforded by a single one of good or poor construction. So long as it is possible for a single check valve to leak, it is possible for two in a series to leak at the same time, engineering journals. The outstanding reports and opinions on this subject are the Report of the Committee on Private Fire Protection Service of the American Water Works Association in June, 1919, the Report of the Committee on Cross Connections, By-Passes and Emergency Intakes on Public Water Supplies (adopted by the Conference of State Sanitary Engineers, Boston, June, 1921), the action of the Board of Water Commissioners, Hartford, Conn., November, 1920, and the Resolution passed by the Fire Protection Section of the American Water Works Association in Louisville, Ky., April 30, 1925.
and the danger of pollution of the public supply in that way is only reduced, not eliminated, by two check valves, unless there is a regular and constant inspection of those check valves.

The object of all concerned should be to equip all private fire service connections so as to secure absolute safety against pollution of public supplies by back flow. A single rule only is suggested to govern the installation of connections between public water mains and private fire systems:

"No fire protection system, having an independent water supply which is unsafe for drinking, shall be connected with the public supply mains unless such connection is so equipped as to positively prevent the flow of water from the piping to the public system."

It is the opinion of your committee that the installation of double check valves may be made efficient in preventing pollution from independent fire supplies if regularly and systematically inspected, but only if such regular and systematic inspection is maintained. The difficulty of securing such regular and thorough inspection in all cases is realized.

Your committee also wishes to call attention to the value of requiring that private fire service connections discharge either into cisterns or elevated tanks where independent water supplies of doubtful quality are in use. Taking the public water to a cistern or tank above the flow line and delivering water to the fire protection equipment therefrom precludes the possibility of backflow.
Where an independent supply is used for private fire protection, the fire service connection from the public mains should discharge either into a cistern or elevated tank at or above the flow line and the protected property required to take water for the fire protection equipment from the cistern or tank to preclude the possibility of back flow.

When such an arrangement is not possible of attainment, double check valves should be installed with proper means for inspection and testing. . . . Such valves should be regularly and systematically inspected, and reports filed as to their condition.

2. Excerpts from the Conference of State Sanitary Engineers' Report Adopted June, 1921.10

The cases of the use of cross connections were divided into two kinds. For the first group, the committee came to definite and prompt agreement, namely, that when an impure independent supply was maintained for normal industrial purposes, any cross connection with a public supply, regardless of the devices that may be installed or the precautions that may be taken, would be an unsafe and altogether too dangerous procedure at any time.

For the second group, where a cross connection is to be made with a private fire protection system using impure water, but where no outlet of water is provided except through fire hydrant, sprinkler plug or hose connection, a somewhat less hazardous situation was recognized. Though the demands for complete safety require that the water served for human consumption must at all times be free from danger and hence connections with impure supplies totally disapproved, the committee came to the opinion that account must be taken of the temporary use in some circumstances of cross connections with effectual safeguards. It was believed that such temporary permission by the State Department of Health in exceptional instances for the use of a cross connection for a fire protection service should not ever become a permanent provision, but after a due period for the development of the public supply for adequate fire protection, the permission would be revoked. An instance of such a course is evidenced by the City of Hartford. Here in 1909 some of the first installations of cross connections with Factory Mutual Double Check Valves, were made. After 10 years had elapsed, an order was issued in 1920 giving the mills until September of this year, 1921, to completely sever all physical connections. The committee has been convinced by the large number of instances of the contamination of the public supply through cross connections that such connections as a permanent measure should never be endorsed.

The Committee recommends the adoption of the following principles:

Principle 1—No cross connections should be established or maintained between the public water supply system and any other water supply system, private or public, unless both water supplies are of safe sanitary quality and both supplies and the connection thereof have received the approval of the State Health Department.

Principle 2—In cases where it is necessary or advisable to supplement an impure private water supply with the public water supply distributed in the same piping system, the public supply must be made available by delivering it into a cistern, suction well or elevated tank, at an elevation above the high water line of such cistern, suction well or tank.

Recommended modifications of above principles for temporary application under exceptional circumstances:

While the committee is of the opinion that full safety demands such complete separation of the public water supply system from other water supply systems delivering impure water, the committee recognizes the relative degree of safety which can be provided by suitable check valve installations on connections between a public water supply and a piping system used for fire protection only.

The committee is cognizant of the fact that such connections may be proper and reasonable under certain conditions, and desires to express the following requirements which should be met in making and maintaining such installations:

1. Such connections should not be permitted where the available public water supply or private fire protection supply is adequate for fire protection purposes.

2. That the fire protection piping system shall not be connected with any other piping system upon or within the property served, and that there shall be no outlet from such fire protection piping system except through sprinkler head, fire plugs and hose connections. This requirement is intended to prevent a flow through check valves except at
times when a sprinkler head, fire plug or hose connection is open.

3. The cross connection shall be equipped with such devices as can most effectively prevent an inflow of water from the fire protection system to the public water supply system.

4. The committee is of the opinion that the most efficient and dependable device developed up to date (aside from the method described in principle 2 above) is the check valve installation recommended by the Associated Factory Mutual Fire Insurance Companies of Boston, Mass., consisting of two gate valves with indicator posts, two check valves of the Factory Mutual type, with drip cocks and gauges for testing, an alarm valve equipped with a recording pressure gauge, a by-pass meter around the alarm valve, all to be placed in a vault of water-tight construction accessible to ready inspection.

5. A systematic test inspection of the cross connection, including periodic examination of the interior of the check valves by the department in charge of the public water supply system, must be provided without which inspections the installations of the cross connections would be a highly dangerous health menace. The inspection must therefore be made reliable, thorough and responsible.

6. The committee views as a self-evident requirement that in every case where a cross connection is being considered for approval a thorough investigation will be made as to local conditions and as to the necessity and advisability of the cross connection and that the local municipal officials will be made fully acquainted with the circumstances and given due opportunity for presenting their views.

3. Excerpts from Engineer's Report, Hartford, Conn.\textsuperscript{5}

In the 10 years' experience in Hartford, with twelve sets of check valves, the records show that eternal vigilance only can keep these valves even passably tight; that they do leak on the slightest provocation; that sometimes both valves have been found leaking at the same time; and that there is no assurance that they will remain tight even for a short period after test.

It is well recognized by all fire insurance interests that proper fire protection to important factory or industrial works requires a secondary supply of water from a source independent of the primary supply. To accomplish this purpose, however, there are safe and approved methods which may be substituted for connections with a polluted source. Such methods of secondary supply, as from tanks and cisterns, are authorized and satisfactory to the majority of engineers versed in fire protection engineering.

From a water supply standpoint a principle is involved which is of practical application and not theoretical discussion. From the very nature of the case no argument can be successfully defended that there is no danger to health through these connections. On the other hand, from a fire protection standpoint, other approved means are at hand to accomplish the result.

4. Resolution passed by the Fire Protection Section of the American Water Works Association at the Annual Convention, Louisville, Ky. (April 30, 1925):

\textit{WHEREAS}, cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water borne diseases, and

\textit{WHEREAS}, check valves and other similar protective devices cannot always be depended upon, be it

\textit{RESOLVED}, that no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

This prohibition to apply to all piping systems either inside or outside of any building or buildings, and be it further

\textit{RESOLVED}, that definite programs should be inaugurated in each municipality to permanently eliminate all other connections.

The editor of the Engineering News-Record stated that “the resolution is in line with action taken a few years ago by the Conference of State Sanitary Engineers, with the regulations of at least one state board of health and a growing number of cities. The need for preventing cross connections is illustrated anew by typhoid outbreaks and deaths due to such connections, as our columns testify every few months.”
Preceding this action by two years, we have the following resolution unanimously adopted by the North Carolina Section of the American Water Works Association in November, 1923:

Resolved, that there shall be no physical connection between the public water system and any private water supply system, wherein it is possible for contaminated water to pass to the public water supply system.

And that the State Board of Health be requested to notify all parties having cross connections that the same be removed or disconnected from the city water supply within a reasonable time.

The following letter of June 3, 1920, from the Chief Engineer, National Board of Fire Underwriters, New York City, to the Engineering News-Record, shows an appreciation of this health hazard:

Sir:—Perhaps it was not so intended, but the reference in the last paragraph of the editorial on “Leaky Cross Connections” in your issue of May 13, p. 939, might readily give the impression that fire protection engineers generally were in favor of cross connections between two supplies, one of which is unsafe or questionable.

The fire protection engineer is not the responsible party in making the connection originally or in its continuance. Insurance standards require, for complete reliability, two independent sources of supply, and the plant management or the municipal authorities may, and often do, use one source which is unsafe or questionable from a sanitary standpoint, for the reason that it is cheaper or easier.

The engineers of the National Board of Fire Underwriters do not, and we believe other engineers should not, favor such connections, but there are cases where they have already been made, and it is not possible, without the charge of discrimination, to refuse credit for them as emergency sources. It is, however, standard practice with many of the insurance bureaus to recommend secondary sources of supply which will be safe, as for instance, a storage reservoir.

The double check valve, designed some years ago for use on connections to sources of doubtful quality, has been permitted by some health authorities and has a satisfactory record. It should be installed most carefully and be maintained under a thorough inspection system.

(Signed) GEORGE W. BOOTH

Although a canvass of all the states has not been made on this subject, the following information has been secured:

Connecticut (recent communication)—“In all complete reports of this Bureau on public water supplies, we call attention to the danger from cross connections and the desirability of removing them.”

Illinois (recent communication)—“It has been our practice in making inspections of public water supplies to attempt to ascertain whether or not there are any cross connections and then recommend to the local officials that such cross connection be abandoned.”

Indiana—Since June 1, 1924, Indiana has required complete physical severance of public from private supplies.

Kansas—Regulation adopted in June, 1925, requires that all cross connections be eliminated on or before January 1, 1926, except where the cross connection is between a municipal water supply and a regularly inspected and approved potable private water supply.

Michigan—Recommends no direct physical connection between public and private supplies, but where this is not practicable has permitted the factory mutual double check valve system.

Minnesota—Since 1918 no physical connections have been permitted between water supply systems that are safe for domestic use and those that are unsafe.

New Hampshire—Feels that double check valves if inspected twice annually afford reasonably efficient protection.

Ohio—Has permitted cross connections between public and private water supplies with the use of double check valves, but has withheld approval of this method of procedure, for it believes that such connections are potentially dangerous.

Pennsylvania—Special permits are required for cross connections and granted only upon special investigation. A few installations of factory mutual double check valves have been permitted, and careful inspections are required. Where the public supply is the auxiliary supply for an industry, and an elevated tank is available, free discharge into tank is required with no possibility of back flow into public system.

Washington—On April 15, 1924, required complete severance of all cross connections, except that existing installations of factory mutual double check valves with provisions for inspection were allowed to remain until January
I, 1927, at which time complete severance will be required.

Wisconsin—Permits no new cross connections. Allows cross connections existing prior to 1924 to continue if protected by double check valves arranged for testing. Monthly inspections and reports are required, and the state board reserves right to require elimination of any cross connections. A recent communication expresses the feeling of the chief sanitary engineer: "We hope to ultimately secure the complete elimination of all cross connections."

Province of Ontario, Canada—Prohibits cross connections except that fire protection systems may be cross connected to public supplies under certain restrictions.

New York State—Cross connections are prohibited in the following twelve villages and cities: New York City, Albany, Altamont, Bangor, Bridgehampton, Buffalo, Canandaigua, Cohoes, Kingston, Port Chester, Rochester, Tuxedo Park.

Among the other states the following is a partial list of the cities in which cross connections are prohibited: Hartford and Stamford, Conn., Cambridge, Lowell and Springfield, Mass., Providence, R. I., Philadelphia, Pa., Cleveland, O., Terre Haute, Ind., St. Paul, Minn., Richmond, Va., Rockford, Ill., New Hanover, N. C.

SUMMARY

To sum up, we find that 4 states absolutely prohibit cross connections; a fifth state prohibits cross connections on new installations; and most of the other states, while recognizing the potential danger, permit cross connections if provided with factory mutual double check valve systems arranged for ready inspection. Within our own state, New York, 12 villages and cities have realized the potential danger from polluted auxiliary supplies and require complete severance.

As to the unreliability of double check valves even with frequent inspections, we have many examples. In Hartford, where weekly pressure tests by the city water department were made with a complete overhaul of the valve three times a year, 61 times the check valves were found to be leaking, 55 times in one check valve and 6 times in both valves.

An inspection by the New York State Department of Health in a large city in that state in 1924 of a cross connection between the public water mains and a polluted fire supply where the cross connection consisted of three check valves and two gate valves, showed that the valves were not tight. At the time of the inspection, in order to test the condition of the check valves, the fire pump was started without closing the gate valve and immediately the pressure gage on each side of the check valves showed an increase in pressure of about 50 pounds per square inch, indicating that at least two of the check valves were partly open and not operating. The hoods on two of the check valves were removed and it was found that the hinges had nearly rusted off, with the result that the flaps on the check valves had dropped down, leaving them about half way open in each case. When last inspected by the city authorities, they had been reported as being in a satisfactory condition.

In 1924 an investigation by the state health department of the status of cross connections in another city of New York State where regular and careful inspections had been made by the city water department, revealed the following facts: A recent inspection made by the city water department of 22 double check valves indicated that 6 sets were leaking in both valves, 15 sets were leaking in one valve and only one installation showed no leak.

Inasmuch as the usual method of testing the check valves is by pressure gauges, the experience of an inquisitive water works superintendent in Canada is worthy of note. He found that in many cases where no leakage was indicated by the pressure gauge, leakage was taking place as shown by a dye test.

Regular inspection, if reliable, may prevent failure of check valves through tuberculation or corrosion but it will not prevent failure due to obstructions of gravel, sticks, and similar substances.
Millions of dollars have been spent in New York State to assure safe water supplies for the people. Leaky check valves on cross connections to industrial auxiliary supplies from polluted sources, with consequent possible contamination of the public supplies, tend to defeat the purpose of this costly expenditure for safeguarding the public health.

For the past 8 or 10 years the question of cross connections has been a matter of considerable concern to the state department of health. In 1918, the system of double check valves of approved design when properly installed in accessible manholes and provided with proper testing and inspection facilities was tentatively approved. Subsequent experience elsewhere and in this state has shaken our faith in the ability of this device to afford the necessary protection. In an actual test in one city in this state 27 per cent of the installations were affording no protection and only 1 out of 22 installations was tight in both valves.

Action on the part of municipalities to secure complete physical severance between the public water supply and private auxiliary supplies, has frequently aroused protests from industrial concerns and fire insurance companies. It is difficult to account for these protests, in light of the information obtained by the Surgeon General of the U. S. Public Health Service in response to a questionnaire on interconnections between domestic and polluted water supplies. This questionnaire was sent out by the Surgeon General to various fire underwriters organizations, and 23 replies were received representing organizations operating in all sections of this country. Of this number, 17 either discouraged the use of double check valves or did not permit their use, while 2 stated they followed the state control. The underwriters who protest against the elimination of cross connections contend that the menace to health through cross connections is slight as compared with the increased fire hazard. The elimination of cross connections, however, need not increase the fire hazard, although it may increase the cost of maintaining an equal fire protection through the use of overhead tanks or underground cisterns. The crux of the matter is, therefore, not a question of health vs. fire protection, but health vs. dollars and cents.

**CONCLUSIONS**

1. The existence of cross connections between the public water supply and any other water supply system, private or public, unless both water supplies are of safe sanitary quality, is a serious menace to health.

2. The pollution of the public water supply and epidemics of typhoid fever and other enteric diseases have on numerous occasions been definitely traced to such cross connections.

3. While the type of equipment for preventing backflow from auxiliary supplies into the public water supply system, making use of double check valves of special design, installed in readily accessible manholes and arranged with facilities for testing, is an improvement over single check valves or the ordinary double check valves, the protection afforded is not absolute nor positive.

4. It is doubtful if the present method of testing double check valves by pressure tests is sensitive enough to reveal small quantities of backflow.

5. The existence of cross connections with check valves subject to leakage and backflow from polluted sources into the public water supply, tends to defeat the purpose of costly expenditures involved in securing safe water supplies for the public.

6. Complete physical severance between public water supplies and polluted auxiliary supplies is the only positive means of preventing such pollution of the public water supply.

7. Inasmuch as overhead tanks or underground cisterns with fire pumps, as auxiliary fire supplies are accepted and
approved by the fire underwriters, the elimination of cross connections need not increase fire hazard.

After long careful consideration of this question of cross connections between public water supplies and water from other sources and the question of dual water supplies in manufacturing and other establishments, the Public Health Council of the New York State Department of Health on November 12, 1925, adopted the following amendments to Chapter VII of the Sanitary Code. These regulations have the force and effect of law in New York State.

SANITARY CODE—CHAPTER VII
Miscellaneous

Regulation 15-a. Certain cross connections between water supplies not permitted—No officer, board, corporation or other person or group of persons owning or having the management or control of any potable water supply furnished to any municipality or water district, shall permit after July 1, 1926, any physical connection between the distribution system of such supply and that of any other water supply, unless such other water supply is regularly examined as to its quality by those in charge of the potable water supply to which the connection is made and is also found to be potable. This prohibition shall apply to all water distribution systems either inside or outside of any building or buildings.

Provided, that, where such physical connections now include two gate valves with indicator posts, two check valves of the special Factory Mutual Fire Insurance design or equivalent with drip cocks and gauges for testing, all located in a vault of water-tight construction accessible for ready inspection, the date of discontinuance may be extended until July 1, 1928.

Regulation 15-b. Permissible arrangements where dual supplies are used—If a potable water supply is used as an auxiliary supply delivered to an elevated tank or to a suction tank, which tank is also supplied with water from a source with which cross-connections are not permitted by regulation 15-a, such tank shall be open to atmospheric pressure and the potable water supply shall be discharged at an elevation above the high water line of the tank.

Regulation 15-c. Non-potable water in industrial plants to be rendered unavailable for drinking—Wherever a potable public water supply is available for drinking and for other personal or domestic purposes in any industrial plant, unless such other supply is approved by the local health officer. If no such public water supply is available, the water for drinking or for other domestic purposes shall be of safe, sanitary quality approved by the local health officer. If the water supply for industrial or fire protection purposes is obtained entirely or in part from a source not approved for drinking purposes, this supply shall be distributed through an independent piping system having no connection with the systems for drinking and for other domestic use, and the outlets shall be so arranged as to be inaccessible for drinking.

BIBLIOGRAPHY