from which general specifications and minimum requirements for piping and accessory equipment can be obtained.

Suggestions for selection and installation of materials based on long operating experience of the district heating industry are given in following paragraphs. More detailed information is available in the *District Heating Handbook*, Third Edition.[10]

Pipe. Either steel or wrought-iron pipe are satisfactory. Welded construction is most desirable.

Valves. Flanged cast-iron valves for pressures under 125 psig are satisfactory. For pressures from 125 to 300 psig flanged-steel and welded-end valves are used. Outside screw and yoke valves are preferred.

Fittings. Forged or rolled steel are used for pressures in excess of 125 psig. Where pipe-line apparatus is to be removable, flanged fittings are preferred.

Expansion Joints. Pipe bends to absorb expansion are preferable wherever feasible in order to eliminate the inspections, maintenance and housing required by slip joints. Slip joints should be guided either externally or internally, or both. Corrugated-type joints should have stainless steel or copper corrugations depending upon operating conditions. Spare expansion capacity should be allowed for contingencies such as higher pressures, superheat, and installation tolerances.

Anchors. Anchors can be of structural steel, special fittings, or U-shaped steel straps which partially encircle the pipes. Anchors should be firmly bolted or welded to a short length of cast or stainless steel set in concrete. Anchors are often fabricated by welding structural steel to pipe and embedding the ends in manhole walls or concrete poured in connection with conduit. Anchors are subject to humid conditions in conduits and manholes, and can deteriorate rapidly. They should be designed for adequate strength, intended life, and the steam pressure to which they can be subjected, with liberal factors of safety and protection from corrosion. Anchors should be attached to both sides of the pipe. Lugs should be welded to pipe on both sides of loop-type anchors to prevent slippage. The cantilever type of anchor should be avoided. Cast steel is preferred to cast iron for anchor material.

Alignment Guides. To assure pipe alignment and proper operation of expansion joints, pipes should be adequately guided. Special precautions should be taken if the pipe deviates from a straight line.

Pressure Reducing Valves. Suitable single-seated valves are preferable. The valves should be selected from the manufacturer's rating regardless of pipe size. Pressure gages are necessary at valve and control points. Valves require some auxiliary source of power for valve positioning, if they are to be controlled from some remote point to regulate terminal pressure.

Traps. To assure adequate drainage of piping, extra trap capacity and large drip pockets should be provided. Extra heavy or corrosion-resistant trap discharge piping is desirable. On steep grades or in high velocity steam mains, special deflector scoops or baffles should be placed in the line to direct condensate into traps.[11]

Supports. Due to humid conditions in conduit and manholes, it is desirable to use stainless steel supports.

Instruments. The instruments required will be the same as for other steam systems as described in Chapter 38, Automatic Controls, or Chapter 52, Instruments and Measurements, with modifications depending on the

records desired with regard to pressures and temperatures maintained or the records of response of the system to varying load demand.[12]

Branch Connections. Branch connections should be made at or near anchor points; if not, ample clearance must be provided around the branch to take care of pipe movement.

Insulation

Insulating materials constitute a primary element of district steam distribution structures and must be suitable for underground service. Insulation should be noncombustible, vermin-proof, moisture-resistant, durable, non-corrosive to steel pipe especially when wet, and able to retain its position in relation to the pipe line. It should be of a type which, if flooded, will dry out and regain its original physical, chemical and insulating properties. It should be relatively unaffected by such chemicals as are usually found in ground or other contaminated waters. It should have the lowest practical heat conductivity consistent with the given requirements.

Insulating properties vary with soil conditions, weather variations, types of conduits used, and, if in tunnels, the amount of ventilation. The selection of insulation to provide for the various conditions is covered in *District Heating Handbook*—Third Edition. Where underground insulation is applied directly to the pipe, copper wire is normally used to band the covering. Insulation may be poured as a monolithic structure in a suitable duct. Where insulation in an existing conduit has deteriorated the line may be reinsulated with a minimum amount of excavating by use of some of the materials used in monolithic conduits.[13] Insulation is discussed further in Chapter 27, and studies of heat loss from bare and insulated buried pipe are given in *District Heating Handbook*[14] and in *Piping Handbook*.[15]

RETURN OF CONDENSATE

If the condensate can be returned to the plant to be used for boiler feed water at an overall cost less than that required to process raw water, the installation of return lines parallel to the steam supply lines should be given consideration. A typical analysis of comparative costs of returning condensate and processing feed water is given in *District Heating Handbook*.[16]

Return of condensate by gravity is desirable, but usually because of terrain conditions or user's return facilities, the condensate is pumped back under pressure.

Pipes carrying condensate are more subject to corrosion than other parts of the system. Care must be taken to give proper pitch to the pipes and to provide proper venting of non-condensable gases. (See Chapter 42, Corrosion.)

BUILDING PIPING AND EQUIPMENT

There are certain fundamental principles that should be followed in the design of a building heating system which is to be supplied from district steam mains. Some of these are unique to district heating and some, although they may apply to any building have been demonstrated to be particularly important when district steam is used. District heating companies have certain regulations regarding the consumer's installation to safeguard the mutual interest of supplier and consumer and to insure satisfactory and economical service. When an installation is designed, local regulations and code requirements[17] should be observed.

Typical service connections are shown in Fig. 2 for low-pressure service