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 a remote point to regulate terminal pressure. (See Chapter 26 for detailed recommendations regarding pressure reducing valves.)

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.[21]

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 43, Automatic Controls, or Chapter 44, 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.[22]

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.[23] Insulation is discussed further in Chapter 32, and studies of heat loss from bare and insulated buried pipe are given in *District Heating Handbook*[24] and in *Piping Handbook*.[25]

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*.[26]

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 55, 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[27] should be observed.

Zoning. Where the hours of occupancy or heating loads differ in various sections of the building, it is good practice to install separate supply lines to the different sections. For example, in an office building with first floor stores or restaurants open in the evening, a separate main supplying the first floor will permit the steam to be shut off from the remainder of the building in the late afternoon. The division of the building into zones, each with a separately-controlled heat supply, is sometimes desirable, as it permits the heat to be adjusted according to variations in sunshine and wind. It is desirable, also, to provide separate lines for water heating and for various cooking or process appliances. In order that zones may operate at the optimum pressure, it is often advisable to install a separate pressure-regulating valve for each. See Fig. 29 of Chapter 26 for typical service installation with separate lines to heating zones and process equipment.

The heat supply should be graduated according to variations in the outdoor temperature. Because of the continuous availability and constant pressure of district steam, the most economical operation and satisfactory heating can only be obtained by the use of automatic temperature control which, except in unusual cases, is well justified. The application of control equipment in various types of buildings is fully discussed in the book, *Principles of Economical Heating*.[28] Various types of control equipment are discussed in Chapter 43.

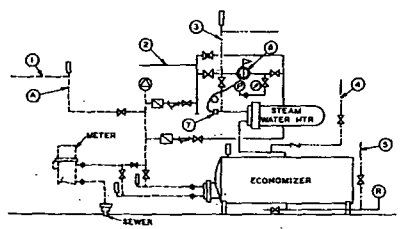
Table 4 .... Suggested Capacity of Traps

Type of Control	Trap Capacity, Lb/(Hr) (Sq Ft of Pipe and Radiation[a])
Continuous or modulating operation, intermittent with *on* periods over 3 hr in duration	⅓
Intermittent operation with *on* periods of ½ to 3 hr in duration	½
Intermittent operation with *on* periods of ½ hr or less	½[b]

[a] Square Feet EDR.
[b] Except for drip traps on mains which should be 1 lb per sq ft EDR.

Rapid draining and venting of the heating system should be obtained by means of suitable traps and air vents in order to obtain rapid circulation and quick heating. This is particularly important with intermittent-type temperature-control equipment. The selection of traps is discussed in Chapter 26. Suggested trap capacities are given in Table 4 of this Chapter. To obtain efficient and economical operation of any system it is imperative that all traps be properly maintained. In a system supplied with district steam any leakage through traps may prevent air removal from the system and otherwise impair its operation. Furthermore, such steam must be condensed and its condensate cooled before being discharged to sewer. This represents a direct waste of steam.

Provision should be made for conveniently shutting off the steam supply at night and at other times when heat is not needed. A considerable amount of heat can be saved by shutting off steam at night and other times when optimum building temperatures are not required.[29] Equipment is available which will automatically shut heat off at night for varying lengths of time, depending upon outdoor temperature.[30]



1. Main Return Line from gravity heating system with all returns properly trapped or pump discharge from vacuum system. With vacuum system a receiving tank with thermostatic vent should be provided at Point A.
2. Steam Supply to Water Heater
3. Hot Water Supply to Building
4. Recirculating Line
5. City Water Line
6. Pressure-Regulator Temperature Control Assembly With Bypass
7. Thermostat Bulb and Tubing

Fig. 2 .... Method of Installing a Water Heater and Economizer in a Gravity Heating System

Residual heat in the condensate should be salvaged. This heat may be salvaged by means of an air-cooling coil, or as is more frequently done, by a water-heating economizer, shown in Fig. 2, which preheats the hot water supply to the building.[31]

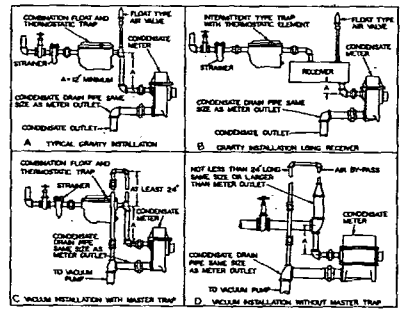
The condensate from the heating system, after leaving the traps, passes through the economizer. The water supply to the heater passes through the economizer, absorbing heat from the condensate. If the hot-water system in the building is of the recirculating type, the recirculating line should be connected *between* the economizer and the water heater proper, not at the economizer inlet, because the recirculated hot water is itself at a high temperature.

Since the heating-system load and the hot-water demand are not coincident a greater amount of heat can be extracted from the condensate if storage capacity is provided for the preheated water. Frequently, therefore, the economizer coils are submerged in a storage tank. Where condensate is pumped, the pump should discharge into a receiving tank equipped with a thermostatic air vent and the condensate should be permitted to flow by gravity through the economizer and meter.

METERING

The *Condensate Meter* was developed for the district heating industry and is an approved method of measuring condensate where all of it can be brought to a common point for metering purposes. Its simplicity of design, ease in testing, accuracy at all loads, low cost, and adaptability to either high- or low-pressure distribution have made it standard equipment with most heating companies.

Condensate meters must not be operated under pressure;



Meter Capacity Lb Per Hr	250	500	750	1500	3000	6500	12000
	Dimension A—Inches						
Diagram B.....	4	4	8	8	8	12	12
Diagram C.....	12	12	15	15	15	18	18
Diagram D.....	12	12	15	15	15	18	18

Fig. 3 .... Condensate Meter Installation Details